Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

APRIL 1952

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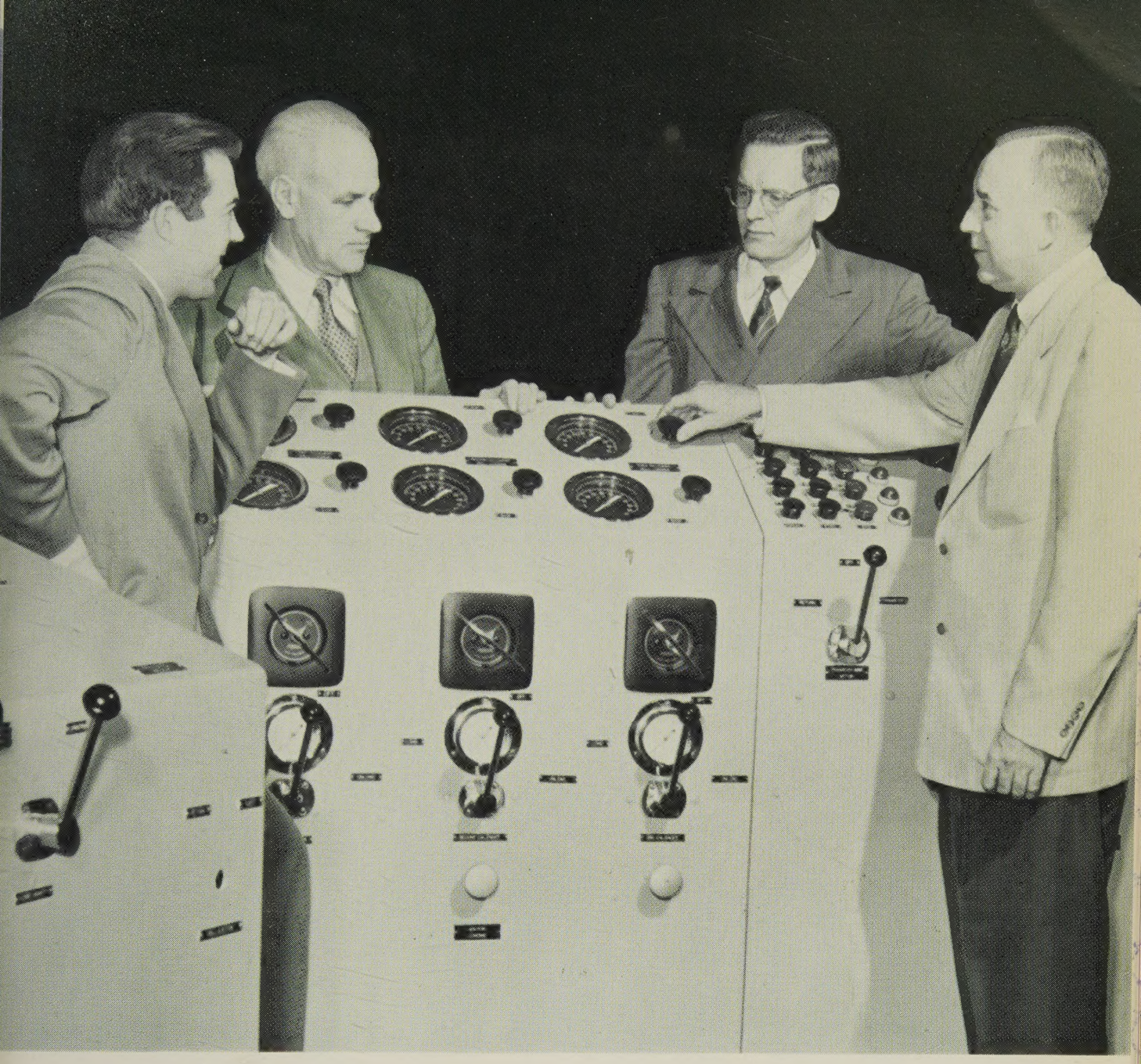

COMPLETE CONTROL of each section of a high-speed, high-production paper machine helps cut operating costs. On the erection floor, Engineering Vice-President Lloyd Hornbostel (*right*) shows sales representatives Carl Swartz (*left*), Fred Erbach, and Don Schamp the features of a new control board to give operators quick, positive, accurate, convenient control of a calender and reel section.—*Beloit Iron Works, Beloit, Wis.*

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Typical wool showroom, where buyers make their selections.

Photographs courtesy of Wool Bureau, Inc.

Out Where Huyck Felts Begin

First, the fleece. From 1,500 classified types, buyers choose only those special wools that meet the exacting requirements of Huyck Felts. In the principal wool-growing countries of the world this discriminating selection goes on. For these must be just certain wools, rare and costly.

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This is the first, and only the first step in making the famous Huyck felts which for 82 years have rendered such essential service to the pulp and paper industry.

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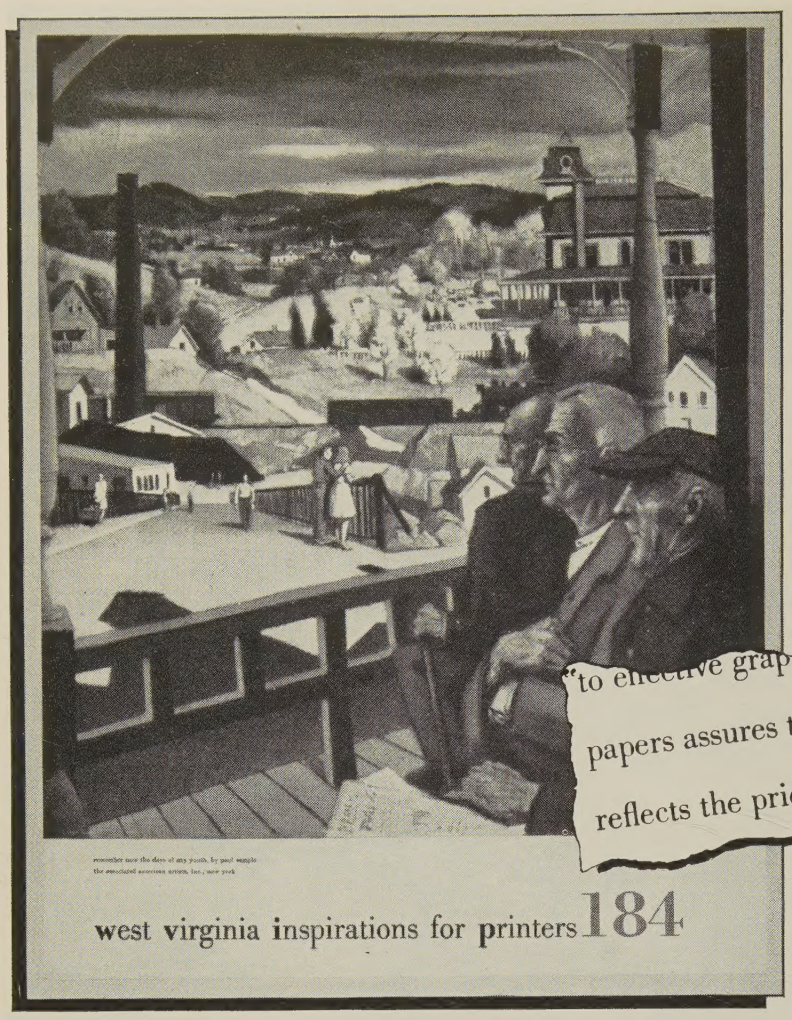

west virginia inspirations for printers 184

And West Virginia Uses Huber Clays

"to effective graphic presentation. the selection of fine papers assures the graphic sincerity which reflects the pride of the advertiser in his own product."

nothing upholds these words more than west virginia pulp and paper company's famed inspirations for printers... each issue truly representative of the highest quality in the graphic arts today. west virginia knows that high-fidelity printing demands quality raw materials for their finished papers... and west virginia turns to huber as a source for filler and coating clays.

huber's 25 years of experience in clay mining and production... their 13 vital laboratory tests* ...assure product uniformity from one clay carload to the next. each huber clay is designed to meet the exacting needs of today's printing requirements. if you want the maximum performance from your papers, try huber clays. write for free working sample.

note: these paragraphs set in lower case, with boldface type used as capitals—an experiment featured in west virginia inspirations, series 184.

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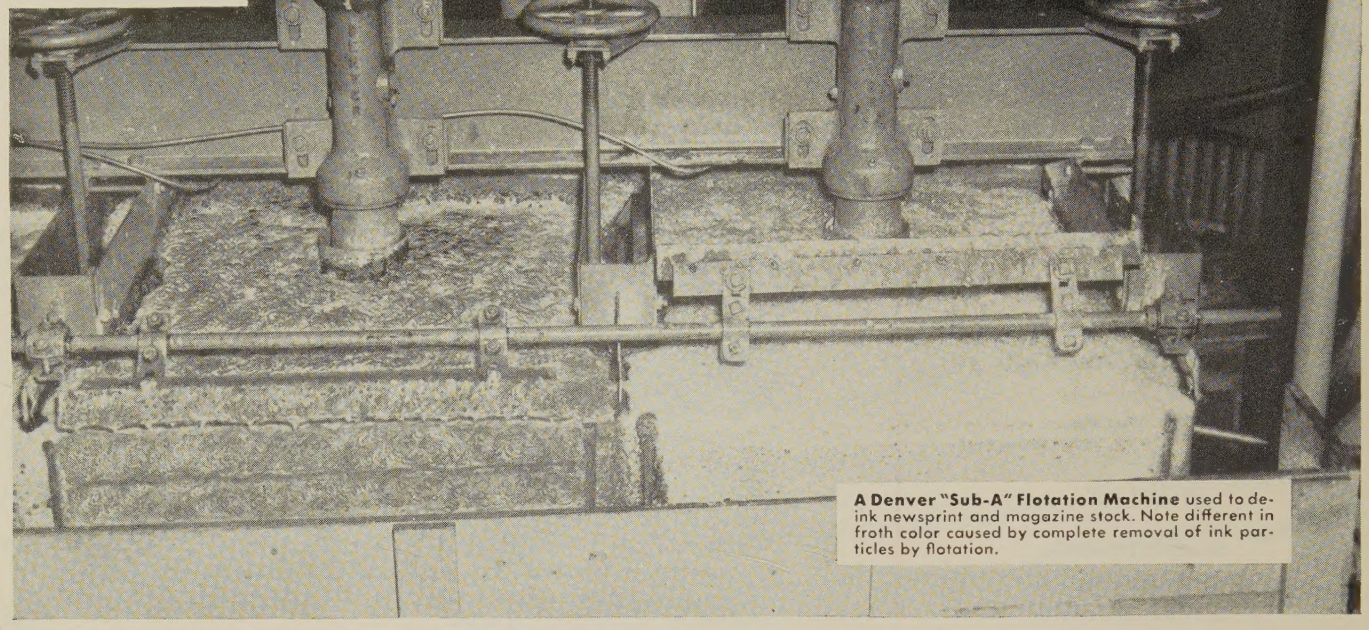
Denver "Sub-A" Flotation



A Denver "Sub-A" Flotation Machine used to de-ink newsprint and magazine stock. Note different in froth color caused by complete removal of ink particles by flotation.

What you should know about Denver "Sub-A" Flotation and how it will work for you...

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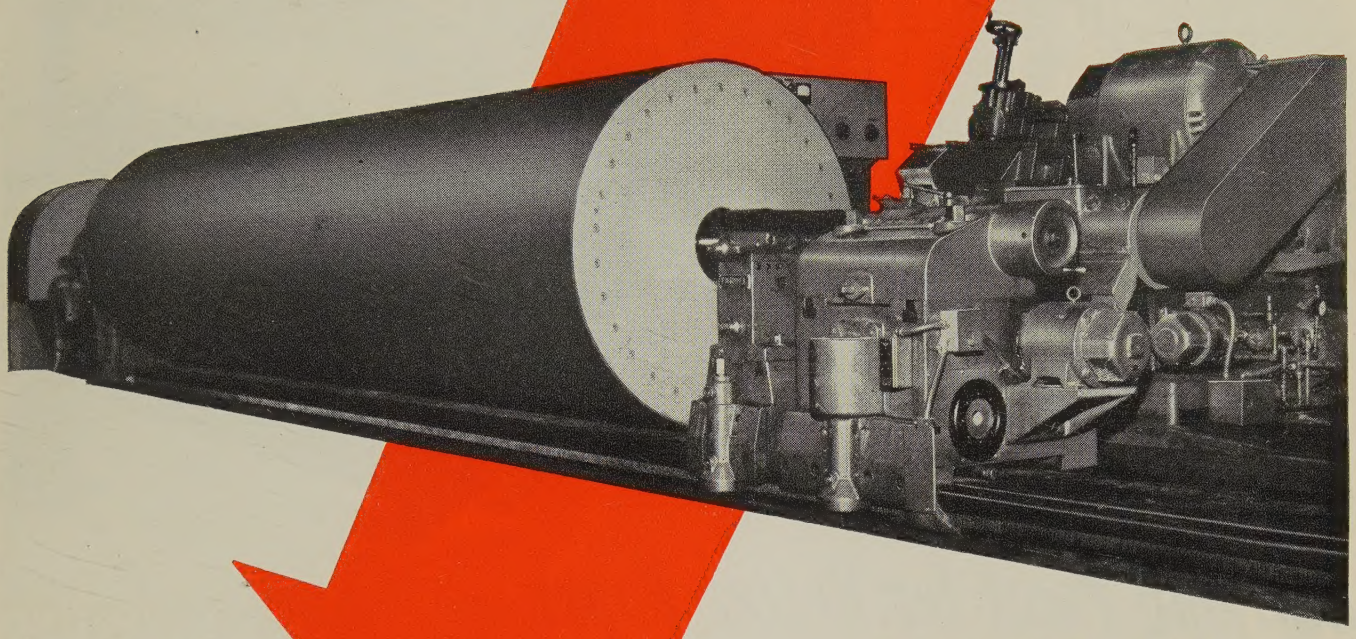

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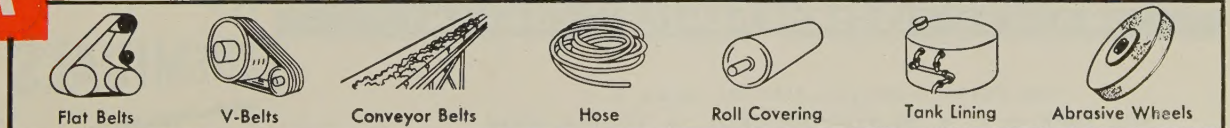

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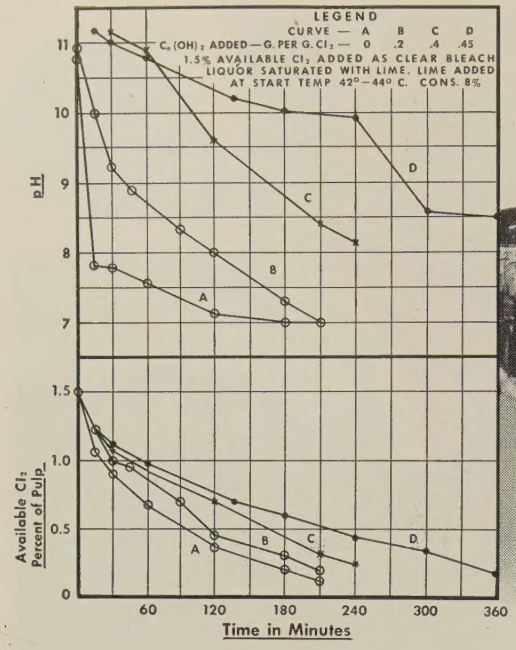
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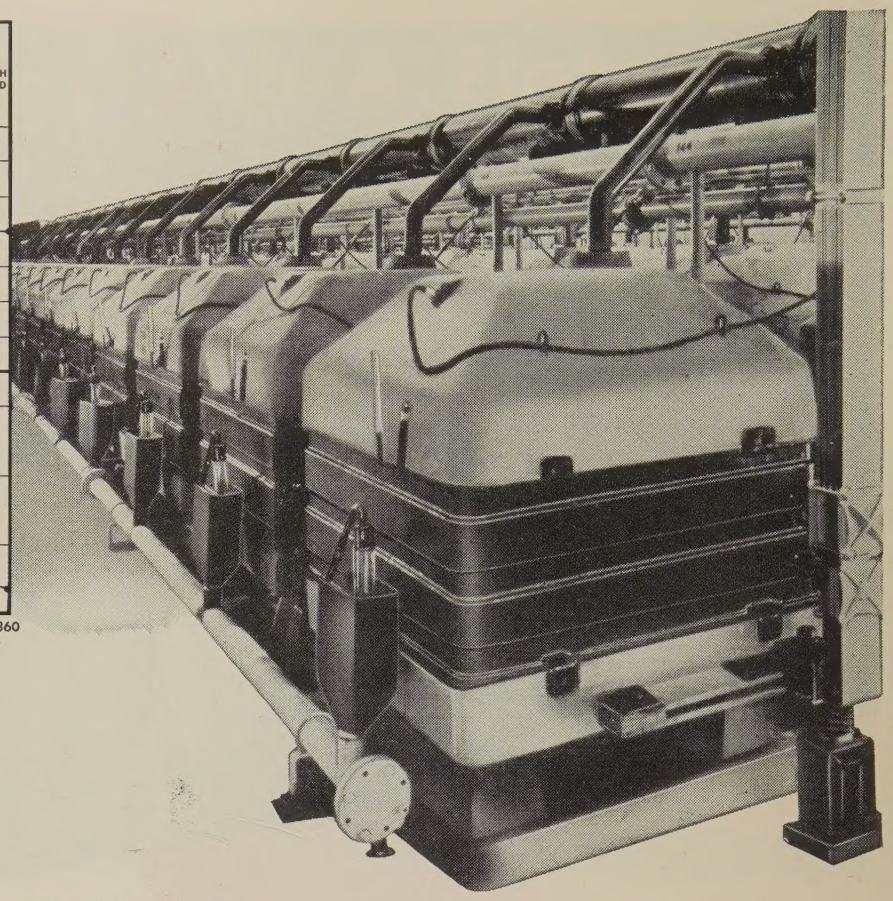
CURVE — A B C D
$Ca(OH)_2$ ADDED — G. PER G. Cl_2 — 0 .2 .4 .45
1.5% AVAILABLE Cl_2 ADDED AS CLEAR BLEACH LIQUOR SATURATED WITH LIME. LIME ADDED AT START TEMP 42°–44° C. CONS. 8%
pH
Available Cl_2 Percent of Pulp
Time in Minutes
60 120 180 240 300 360

Effect of lime additions on pH and rate of chlorine consumption in a hypochlorite reaction with chlorinated sulfate pulp.



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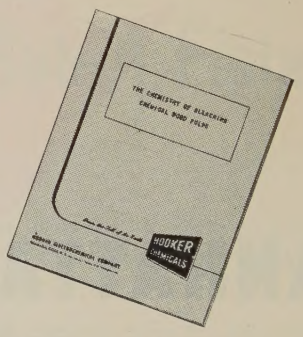

Send for This Helpful Bleaching Data

Bulletin No.

- 201 Process and Equipment for Making Bleach Liquor for Use Without Settling
- 211 Chemistry of Bleaching Chemical Wood Pulps
- 214 What Do We Know About Bleaching?
- 236 Importance of pH and Catalysts in Bleaching Operations
- 242 Production and Use of Unsettled Bleach Liquor
- 243 Procedures and Brightness Grades in Bleaching Sulfate Pulps

From the Salt of the Earth

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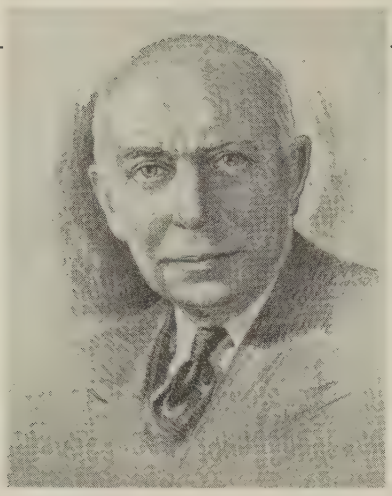
RESEARCH IS DISTURBING

D. C. EVEREST



D. Clark Everest

I AM delighted to have this opportunity to again meet with my friends in Ohio. My invasion into this territory dates back to the Dayton flood when I had a rough time getting away from here, and a year later getting all steamed up on aviation when I was in this section for the homecoming of the Wright brothers and Alice Roosevelt's balloon ascension.

Being about 26 years old at the time and in the course of building Marathon at Rothschild, I still had time to help finance the building of an airplane which made several flights. The pilot and designer, whom another fellow and I were financing, always flew at 100 feet elevation as that seemed to be a good height from which to fall for instant death in case anything went wrong. I went along with him on one flight despite the hot oil which burned the back of my neck as it sputtered out of an old Ford engine in a new and unusual design of a pusher biplane. In due course, it finally came to rest where the Catholic Church now stands in Rothschild. While no one was killed in the experiment, some of us got nosey about future developments, not only in aviation, but a few of us thought research might work in the paper industry from which we were then receiving meager salaries as compared with the munificent sums which you fellows pull down today.

I picked this subject "Research Is Disturbing" as I considered it a thought-provoking subject. If you don't get people to thinking and arguing about some phase of the business you are sunk. I remember well when Noah Bryant of Bryant Paper Co. sprang his new idea about cooking certain types of old papers and making new book papers out of them. Noah had no technical training. He only knew what soda ash, lime, and bleach powder would do to the inks in old papers if properly cooked and washed. For a while his so-called "research" was disturbing, and I doubt if Mr. Bryant, for whom I worked, ever knew what technical research meant. He just used common sense and, aided and abetted by one of the paper distributors from Cincinnati, Colonel Chas. B. Wing, Bryant hooked all the Government contracts of any consequence which Bryant Paper Co. could make by their process.

D. C. EVEREST, President and General Manager, Marathon Corp., Rothschild, Wis.

This did not affect all the mills in this vicinity, but I well remember Peter Thompson, Mr. Friend, and many more from this vicinity coming to Kalamazoo to talk with Messrs. Bryant, Milham, and King as to what this new development was going to do to the paper industry. Most of them thought it would wreck the business forever. To top off the circle of flow of materials, Colonel Wing made a deal through Louis Hopfenmaier in Washington to make a long-time contract for all the accumulation of old papers from various Government agencies. There was a tremendous waste in Government printing the same as there is today and about as fast as Bryant shipped the new paper to Washington the various agencies would ship the overissues and excess printed publications back to Bryant. It really became a conversion cycle with Bryant buying mighty little primary pulps for make-up.

Incidentally, at the early age of sixteen, I was the Government custodian who had to swear that all these Government records, overissues, etc., had been destroyed. Once I had a mess on my hands; I received two carloads of drums used by the United States troops in the Mexican War. These should have been shipped to Bannerman's Arsenal down on the Hudson River, which many of you may have seen on an island in the Hudson as you approach New York. He sells this junk to collectors and South American revolutionists. If you have the dough you can equip a revolution there any time, providing you are not fussy about the time your equipment was manufactured. You can, at least, make a heck of a lot of noise with the stuff Bannerman still sells.

With customary Government regulation over 50 years ago, I, as custodian, was over two cars of drums and short two cars of waste paper for over 6 months, and poor old Bannerman was over two cars of waste paper and short two cars of drums. I didn't mind except it was a nuisance to have it on my daily report every day, but Bannerman had sold his drums and they were resting peacefully for 6 months in Kalamazoo. There hasn't been much change in Government procedure since that time.

Never before have I rewritten a talk which I was to make, but have usually made only minor corrections. Since Paper Week in New York, however, and particularly since the industry meeting on February 22 at which Sydney Ferguson presided, I have decided that time is too short to indulge in platitudes. In this instance I have thrown my first written talk away. At the New York meeting Sydney was very gracious; he included me with Moses and Aaron and all the prophets of Biblical times. As I arose to speak I visualized myself as a sanctimonious stuffed duck arrayed in flowing robes and with a long beard, my right hand raised and the index finger pointing heavenward in the attitude of Old Doc Munyon, when he used to advertise some kind of pills which would cure everything from fallen arches to cerebral hemorrhage. Incidentally, when we talk about p-r-o-p-h-e-t-s I have found that unless you produce some p-r-o-f-i-t-s you will find yourself engaged in working on some other project, and it may not be connected with the paper industry.

I was in on the organization of TAPPI back in 1915, and while, from the standpoint of technical education, I had no

Products for the paper industry

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more business around there than a goat, I did have ordinary horse sense enough to know that you and your predecessors were the people who would make a manager's job difficult—I knew "research would be disturbing." I had a good memory and I merely parroted your jargon. It was a great experience. When someone came up with pH I had no more idea what they were talking about than the man in the moon, but I kept my mouth shut and my ears open and soon I could discuss pH as glibly as anyone around the shop.

It has been the same with many other developments you have made. I have tried to keep pace with physicists, chemists, and every other branch of technical education, even to monkeying around with geneticists, pathologists, entomologists, ornithologists, soil experts, water table and control technologists. In fact, I have tried to keep pace with all the boys who have anything to do with growing trees on which this industry is absolutely dependent. This gets to be a wide field of scientific knowledge and the trick of the whole thing is frequent contact with those who know, keep your mouth shut, look wise, and if you get bear-trapped into talking—say what you have to say in a few concise sentences. If you pronounce some axiomatic truth, no one can successfully beat you down.

As I size up the situation today, there are three groups in the paper industry who are sitting in the "king's seat." Their position is predicated on a law which is as old as the hills, the law of "supply and demand." If some of the other departments of the industry paid more attention to that law, particularly the sales departments which are sometimes afflicted with "hot pants," the whole industry would be better off financially. In your own case, as members of TAPPI, the demand for technically trained men is now, and will be for for many years, greater than the supply. If any of you are mixed up in any way with educational institutions you know that the student body is growing less in numbers. You have passed the peak registration with the expiration of GI benefits.

Then, to make the situation more difficult for industry, I have been informed by men in Government who should know what they are talking about, that by 1955—65% of the engineers of every class will be employed either directly or indirectly on Government projects, and you just don't make good scientists overnight. I asked the question, "Do you mean those who have graduated as bachelors, masters or doctors heretofore, or do you include those who will attain their degrees by 1955?" I was promptly informed that they meant those who had previously attained their several degrees and those who would receive them by June, 1955. This means that all industry will have is only 35% of the technical brains to deal with their own normal or, let me say, civilian problems. Such a situation is alarming. If I had a boy who had any promise of being a good scientist or technician in any field, I would try to steer him in that direction in his educational program.

I used to think that there were two fields in engineering which had not been thoroughly explored and I thought of temperature and pressure. Through pounding away at these two ideas, several things happened which have proved beneficial to me and my associates, but now, with all the recent developments involving nuclear research and many other things, we will find that to old established concerns "research will be disturbing." Everyone in this industry has got to keep up with the parade; otherwise, he is a dead duck. TAPPI makes it easy for the laggards because through your "pride of authorship" you tell all the slow pokes all you know with the result that they get a free coat tail ride for mighty little investment.

That is true of so many of the association efforts in this industry. I think this industry is different from any other industry. We are so imbued with friendship and brotherly love that some of us carry the nonprogressive factions in the industry along on our backs whether they like it or not. I think probably members of TAPPI are entitled to some kind of a ticket to heaven, as there are mighty few people left who do as much for their competitors.

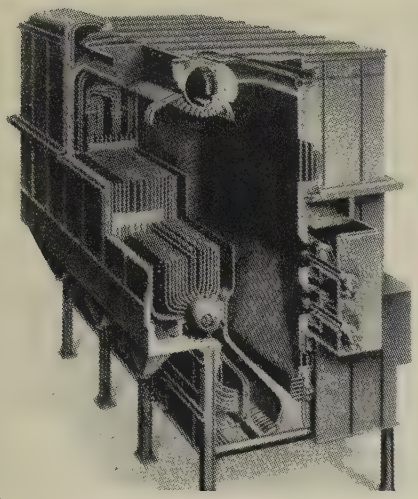
I mentioned three factors in the industry which have been responsible for its tremendous development within the last 20 or 30 years and particularly the last 6 years. I don't think people realize it, but within 6 years the consumption of paper and paperboard has increased 61.75% in pounds—not dollars. No other industry can show such an advance, unless it be the pharmaceutical industry which only recently developed all the vitamins, antibiotics, and other products which doctors administer at the slightest provocation and which you buy at the drugstore and are faced with at every meal to promote this business of synthetic living. The increase in consumption of paper and paperboard of 61.75% in 6 years is no mean accomplishment.

Coupled with TAPPI's efforts, and I give you first place in this program inasmuch as your association was organized in 1915, is the American Paper and Pulp Superintendents' Association. I recall distinctly when Fred Boyce and a number of forward looking superintendents organized that association. Prior to that time everything done in the way of advancement in the art of papermaking was a deep, dark secret and the only way someone in some other mill learned of it was through some felt, wire, or other supply salesman who had picked up some information and used it as a means of ingratiating himself with the next customer. Those supply boys, and for a year and a half I was one of them, had Western Union skinned a mile as a means of communication for paper mill happenings. The Superintendents' Association has done a wonderful job and time was when some of them didn't think too much of TAPPI. Some of the technical men had a "holier than thou" attitude which was pretty hard for a sixth or eighth grader to swallow. This attitude has been eliminated, many of TAPPI's members are superintendents and many superintendents are TAPPI members. We have all learned that the other fellow is not the kind of character the President of the United States classifies all of his opponents.

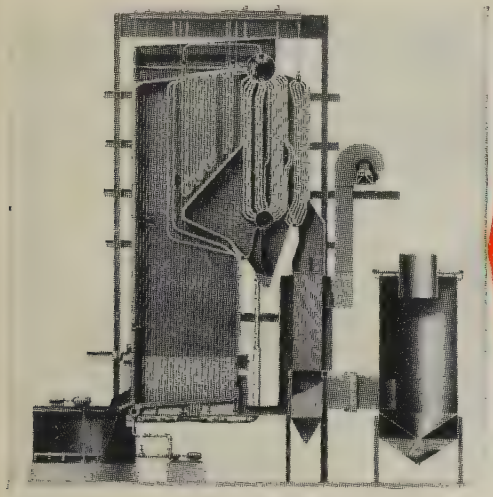
Another group which has helped to make this tremendous increase in production possible is the management and the engineers engaged in building equipment for us. Their work has been outstanding and their cooperation with the industry has resulted in our ability to outstrip all other countries in production per inch of face of driers. While I am now able to buy a good headbox for a cylinder machine for the same price I paid for three complete paper machines in 1909, still I do not object to that as I am merely selling machine hour time and I sell a lot more pounds per hour and at somewhat higher prices. The three factors—TAPPI, the Superintendents' Association, and the machine and equipment builders have made it tough for management.

There was a time when mangagement could go along for a month at a time without being unduly alarmed about what their competitors were doing, but not lately. Now, no two days are alike; if it isn't a new process development it is some new gadget designed to increase production, save sulphur, steam, or something else. Everyone in the organization has a pet project which is just about to save the Universe. The poor old manager has to sit around and have the daylights scared out of him as he visualizes some competitor who is about to put him out of business. With all this galaxy of talent around him, he is somewhat confused as to which project he should spend the meager amount of dollars he has in the bank, after providing the necessary amount of tax dollars for his good old silent partner, Uncle Sam, who never invested a cent in the business nor has taken a risk of any kind, either at the time the concern was organized or since. Then the stockholders feel they should have some return on their investment as they have a habit of eating from which they do not seem to readily recover.

Management also has a few labor union contracts, and the laws governing these change from day to day and some-



BOILERS—B&W boilers have a long and outstanding record for low-cost steam generation in pulp and paper mills. They span a range of types and sizes to satisfy every requirement of capacity, space, temperature, pressure, fuel, and method of firing. Each type combines the dependability of job-proved design with every economy of standardization commensurate with flexibility.



RECOVERY UNITS—Efficient chemical recovery and reduction, along with maximum steam generation per ton of pulp, are combined with economical operation and maintenance in B&W Recovery Units. Installations for burning waste liquors of the kraft, soda, and bisulphate (magnesium, calcium, and ammonium) processes have a total recovery capacity of over 16,000 tons. B&W recovery units were the first provided with automatic soot blowers to eliminate routine hand lancing.

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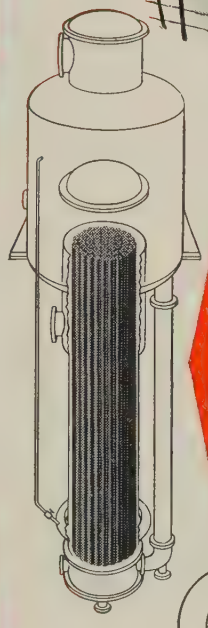

TUBES—Seamless and Welded steel tubes are made by B&W in a range of carbon, alloy, and stainless steel analyses to satisfy every requirement for condensers, evaporators, heat exchangers, recovery units, boilers, and other paper mill applications. Modern improvements in pulp and paper processes impose a greater variety of tubing requirements than ever before. B&W Tube Representatives offer a wealth of experience on tubing problems to help users determine the analyses best suited for specific operating conditions.

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times twice a day. If you fellows sell the manager an idea and he finds, after all the "must" items are taken care of, that he does not have enough dough left to carry out the plans, he engages in a little project known as "doing additional financing." This only brings him contact with auditors, S.E.C., Blue Sky Laws in 48 States and, if his stock is listed, he also gets clearance from the New York Stock Exchange. Of course, there is also a group of underwriters and at least three firms of lawyers.

After he sells the stock and gets the money, he then arranges with seventeen different agencies to get clearance to build, and allotment for materials, finds a contractor in whom he has confidence and, finally, gets the thing built and in operation only to find that you or some other bunch of smart cookies have discovered an improvement on the process which only a year before he started to provide for. A manager's life is really a right merry existence. Someone has said that today management does not have a thing to do—not a thing to do but *work*. But most of us in managerial positions like it, at least we do not get into a rut; if we do—God help the business.

I do not profess to be a sad-voiced Gabriel Heater, a Walter Winchell, or a Drew Pearson, but, nevertheless, I predict that in the manufacture of pulps of every known grade, made from species of wood now commonly used, during the next 5 years research along that line will be more disturbing to management than in any 15-year period, unless it be the time when sulphite pulp was introduced by German chemists back in the 1870's. This will come about in new cooking methods, the use of hitherto unused species of wood, and will be applicable to all grades of unbleached and bleached chemical pulps and may extend to mechanical pulps.

After these pulps are perfected, the work will then extend to paper and paperboard and with the blending of these new pulps you fellows will have your work cut out for you. You will probably have frequent contact with the technicians employed in the printing industry—possibly some from Cincinnati. We will pass through another period of indigestion and stomach ulcers. Anyone connected with the industry from research and manufacturing to the sales force will come in for his share of "stress and strain" including management. But with all the problems and work we have ahead, it is much better than dying of dry rot.

In reporting my New York talk, someone called me a "perennial optimist." Perhaps I am, but I have never wasted a lot of time in preparation for a depression which never happened. Of course, we have had depressions and probably always will have, but they will be of shorter duration. How many years out of the past 50 have we had tough going in this industry? Perhaps ten at the outside. Then, why predicate your whole program on what happened 20% of the time? One may stick his neck out in making predictions, as it is difficult to outguess the gyrations of Government purchasing agencies and even some civilian mob action. There are, however, 154 million people in this country, a new crop of children every year, and doctors have found ways to make older people live longer.

The whole setup points toward a more rapidly increasing population. From "birth certificate to death certificate," children are our customers. The potential is terrific. When I got into this business the per capita consumption was 58 pounds—today it is about 415 pounds. Some increase! Since December, 1945, 6 years ago, consumption of paper and paperboard increased 61.75%. People say that this is temporary and brought about by war conditions. That may be true to some extent, but the appropriations for war expenditures in 1952 are away ahead of 1951. The trouble is that people don't realize that any new development in the use of paper or paper products may be an innovation this week, but within a short time it is "old stuff" and becomes a part of this high standard of living which we boast about in this country. Some people talk about nonessentiality, but I challenge anyone to name one product that might be classified as nonessential which involves any amount of tonnage when you are dealing with a consumption figure around 32 million tons.

No one ever hears much about the paper industry in these various business outlook surveys, but I would respectfully call your attention to the fact that the consumption of paper and paperboard is about one third that of steel, which gets all the "limelight" in any of these business surveys.

My guess is that when this year is over it will top all previous years in the consumption of paper and paperboard. I appreciate we are going to have to go pretty fast during the remaining $9^1/_2$ months of the year to effect the necessary production. The demand will be there even if we cannot meet it with the available supply. Newsprint is included in the consumption figure, but Canada will have to meet that increased need to the extent of at least 80% of the increase, as I do not believe domestic mills can increase capacity to meet demand. I feel certain there will be a substantial increase in consumption of newsprint and magazine papers as the best informed advertising associations say that lineage will be increased above 1951, and so far as newspapers are concerned, they always have an increased consumption during an election year.

As I see it now, consumption of paper and paperboard in 1952 will exceed 32 million tons. You are the men who will be called upon to help out in meeting this demand.

In conclusion, let me say that I still stick to my text that research is disturbing and has been since Adam engaged in his first biological experiment in the Garden of Eden and has continued to the present time. It will continue long after we are gone, and the work you are doing now will be the recorded history of research and development which will be used by countless generations which follow us.

Presented at the meeting of the Ohio Section of TAPPI and the Cincinnati Club of Printing House Craftsmen, Middletown, Ohio, March 13, 1952.

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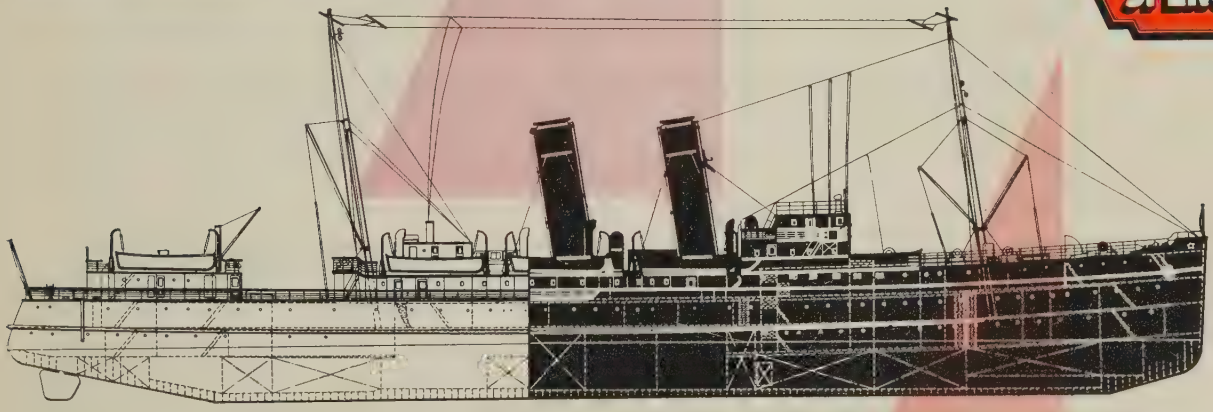

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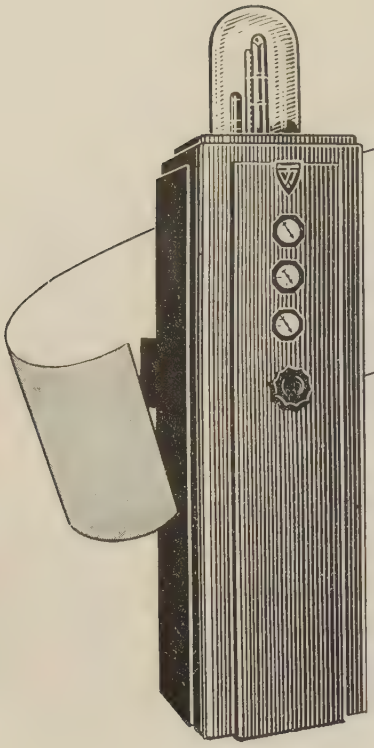

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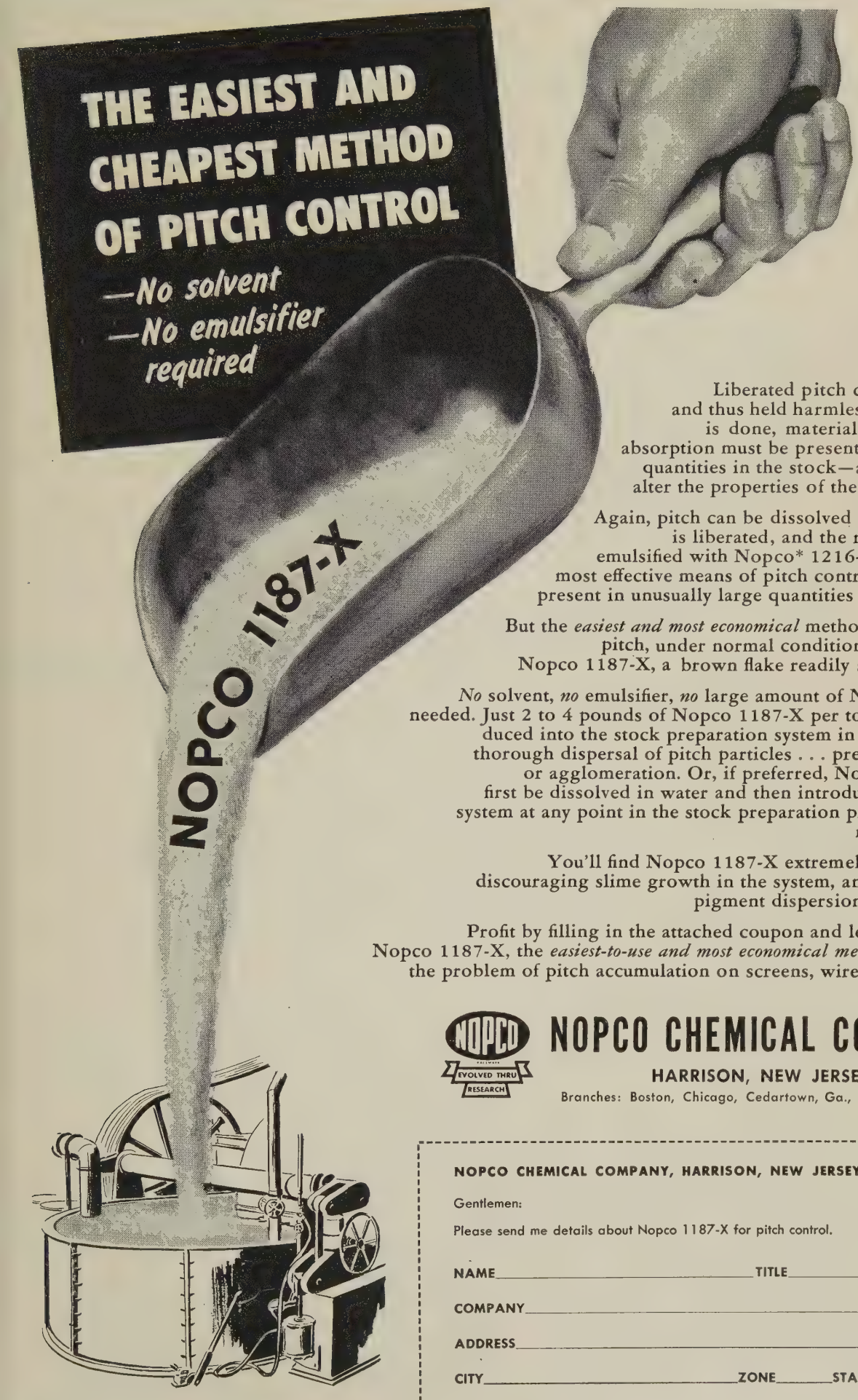

Liberated pitch can be absorbed, and thus held harmless. But when this is done, materials used for pitch absorption must be present in considerable quantities in the stock—and this tends to alter the properties of the pulp and paper.

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No solvent, *no* emulsifier, *no* large amount of Nopco 1187-X is needed. Just 2 to 4 pounds of Nopco 1187-X per ton of fibre, introduced into the stock preparation system in dry form, assure thorough dispersal of pitch particles . . . prevent flocculation or agglomeration. Or, if preferred, Nopco 1187-X can first be dissolved in water and then introduced into the wet system at any point in the stock preparation prior to the paper machine screens.

You'll find Nopco 1187-X extremely useful, too, for discouraging slime growth in the system, and for improving pigment dispersion in beater stock.

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TAPPI Nonfibrous Raw Materials Report—1951

E. N. POOR

Pulp and paper production continued at an overall high rate during 1951 although weakness in certain segments of the industry was noted during the year. The demand for chemicals was strong with several vital raw materials remaining in short supply. Some allocation was found necessary in the domestic market after provisions for export.

A summary of information on a number of important nonfibrous raw materials is given below.

SULPHUR

1. Availability. Sulphur in 1951 was in short supply. Production, which was almost two and one half times the 1935–39 average, was ample for domestic needs alone but not sufficient to meet both domestic and foreign demand. The demand from countries overseas was supplied under government direction in accordance with an export quota system established January 1. The system, while resulting in a small reduction in exports compared with those the previous year, had the effect of maintaining such shipments at a high level. As the amount of sulphur remaining after export was less than enough to meet the full domestic demand, it was necessary for producers to allocate sulphur in the domestic market. Freeport Sulphur Co. allocated on the basis of 85% of sales made during the twelve months ended Sept. 30, 1950.

2. Price Changes. Domestic prices of the major producers continued to be $21 to $22 at the mine.

3. New Uses. While the demand for sulphur continued to increase, there were no important new uses reported during the year.

4. Substitutes. The sulphur shortage stimulated efforts to conserve sulphur in connection with its use but no significant substitutions of other materials for sulphur took place.

5. Outlook for 1952. Although many projects are under way to increase the supply of sulphur, most of them will require a considerable time to complete, and it is expected that the total demand for sulphur in 1952 will continue to exceed the supply.

SODA ASH

The market for soda ash is in normal supply. Manufacturers are producing at plant capacities. It is believed that this condition will continue through 1952, barring any unforeseen changes in world conditions.

No price changes have occurred since Oct. 1, 1950. Light soda ash in bulk continues to be quoted at $1.20 per cwt. f.o.b. producer's plant. Contracts are now being solicited for 1952 at this level.

Substantial quantities of soda ash are being used in semichemical pulping. The process has trebled its pulp production since 1945 from 1000 to 3000 tons per day. It is expected that the semichemical pulping process will continue to expand materially during the coming years.

Soda ash continues to be the cheapest and most commonly used form of alkali for pulp and paper manufacture. It can be converted readily to caustic soda, sulphite, sulphide, and/or hypochlorite-basic chemicals used in the industry. No economic substitute has been found to replace soda ash.

LIME

Lime has been and still is in short supply at present. There seems to be enough tonnage to go around, but there is at present no surplus of lime and if the new plants (chemical and paper mills) that require lime, start operations this year, the lime producer will be hard pressed to supply this additional tonnage.

There is nothing at present that indicates an increase in the mill price of lime. However, it is fairly certain that the delivered price on lime will be higher in 1952 due to increase in freight rates.

The production of chemical lime in 1952 will be increased somewhat due to several lime manufacturers increasing their present plant capacity or building new plants. It is not believed that this increase in production will indicate that there will be a surplus of lime in 1952 but will assist greatly in supplying lime to new defense plants that are going to require lime in the early part of 1952.

It is very important that consumers of lime place their orders with their respective suppliers as early as possible as there is at present a shortage of railroad equipment and it is felt that this shortage of cars will continue through most of 1952. It would also be very helpful for all regular consumers of lime to require their supplier to load their cars at full capacity.

CAUSTIC SODA

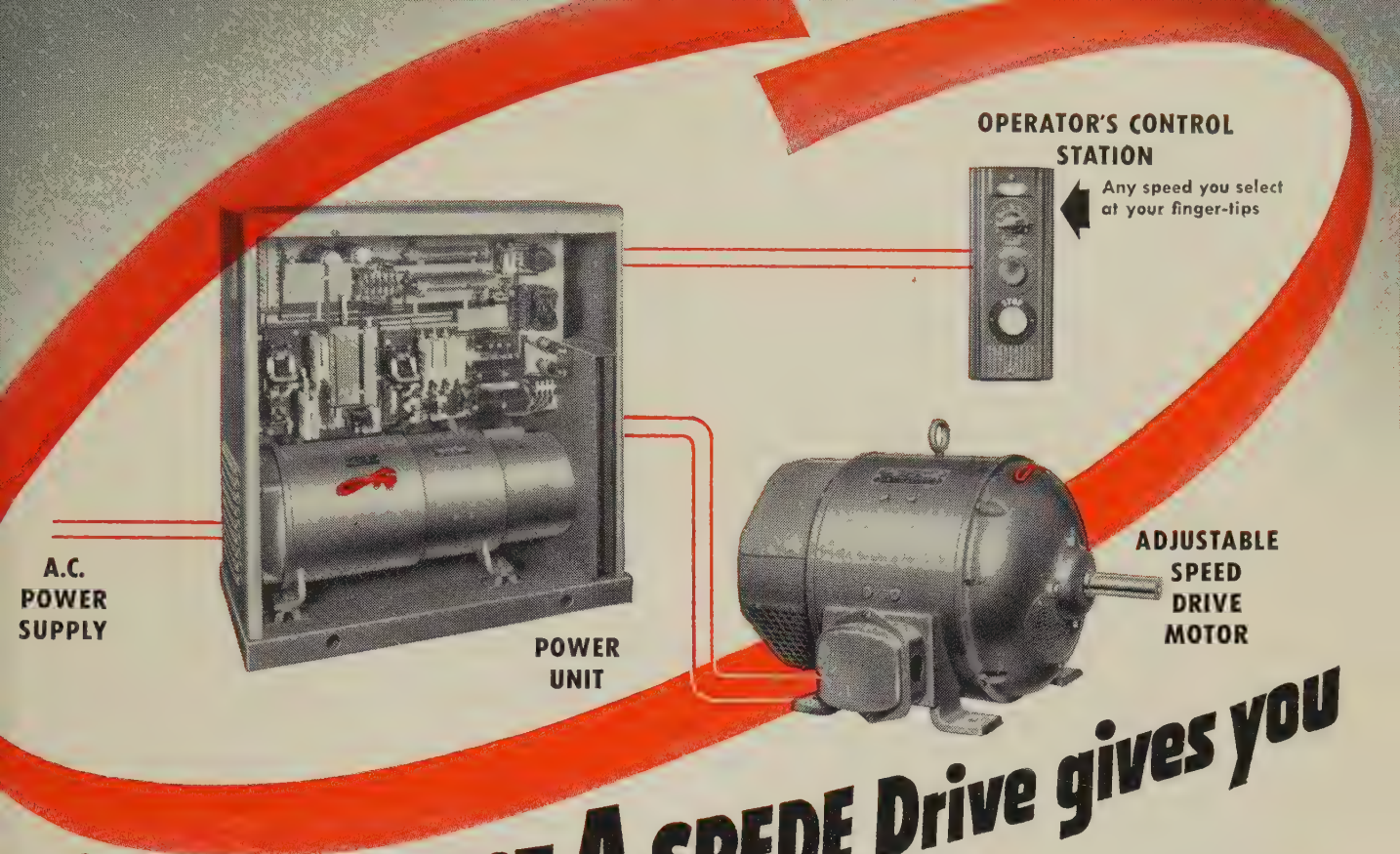
1. Availability. Caustic soda is generally available today, and it is not anticipated that there will be any difficulty in supplying the demand as new electrolytic chlorine and caustic producing facilities come into operation. It is possible, however, that certain grades of caustic, such as solid, flake and possibly 73% liquid, may be tight at various times due to limitations on evaporating capacity in certain plants.

2. Price Changes. It is not expected that there will be any significant change in the price of caustic soda during the next year.

3. New Uses. There are no new uses requiring substantial quantities of caustic but expansion of existing uses, such as for rayon production, will tend to absorb most of the new productive capacity. In numerous instances, paper mills are turning to the use of sodium hypochlorite using caustic soda in place of lime in the preparation of this bleaching material.

4. Substitutes. In view of the availability of

E. N. Poor, Member TAPPI; Chairman, Nonfibrous Raw Materials Committee; Hudson Pulp & Paper Corp., Augusta, Me.



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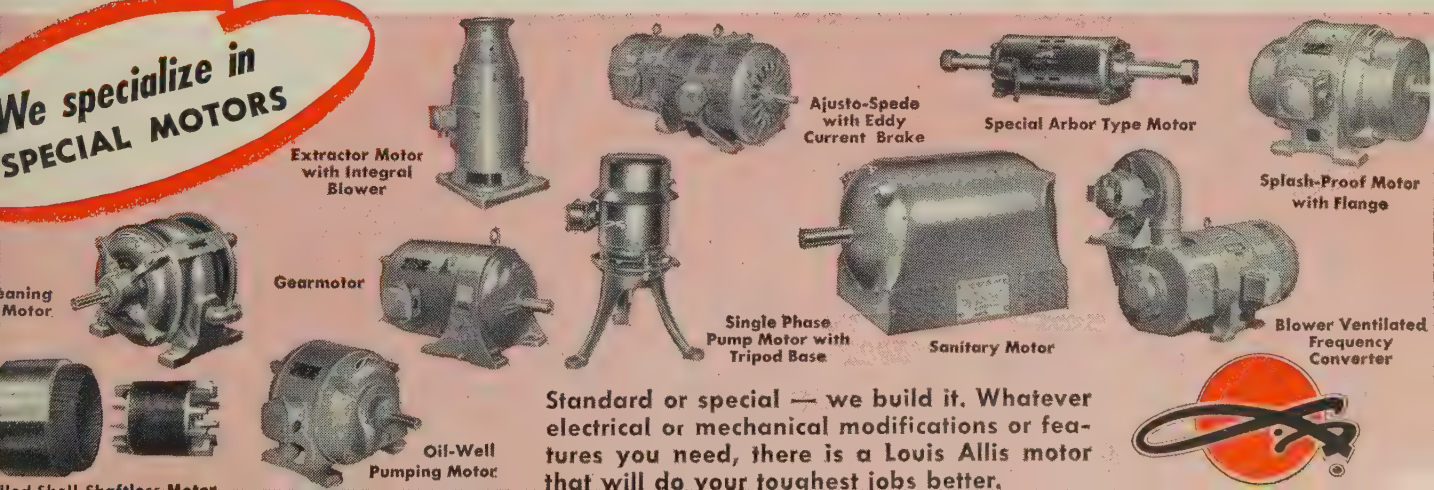

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caustic substitutes are not pertinent to the present situation. In those cases where soda ash is causticized to produce caustic soda, the demand for soda ash will be such as to force some use of caustic as a substitute for ash.

5. Outlook for 1952. In all probability, there will be no problem in meeting the caustic requirements during 1952.

CHLORINE

1. Availability. Chlorine has continued to be short in supply throughout 1951. The production has increased considerably, but the demand still exceeds the supply. If materials of construction are available there will be about 3000 tons gas capacity built in the period 1951–53. This is an increase of about 45% of the current capacity and will cost about 300 million dollars. Some of this new capacity will provide merchant chlorine, but how much cannot be forecasted at this time.

2. New Uses. The old uses prevail and the new uses are mostly in the field of chlorination of hydrocarbons.

3. Substitutes. There is no substitute in any quantity, and it is even proposed to supplement the short supply of sulphuric acid with hydrochloric acid if hydrochloric acid, by any means, including the synthesis with chlorine, can be had.

4. Outlook for 1952. As stated above, if materials of construction are available in 1952, a portion of the 3000 tons can be built and operated in 1952. How much that tonnage will be and what part will be merchant liquid chlorine, it is impossible to state.

PEROXIDES

1. Availability. The consumption and the availability of hydrogen peroxide and sodium perioxide are increasing with growing demands.

2. Price Changes. The market prices for hydrogen peroxide and sodium peroxide are expected to continue reasonably stable.

3. New Uses. Peroxide bleaching of groundwood, as well as mixtures of groundwood and sulphite pulps, is increasing in tonnage.

There has been an expansion in the use of peroxides in the recovery of waste papers containing a substantial percentage of groundwood.

Peroxide processes for bleaching sulphite and sulphate pulps are in commercial operation.

4. Substitutes. Hydrosulphites and hypochlorites are being used for some special applications in the bleaching of groundwood, e.g., hydrosulphite for bleaching West Coast woods and hypochlorite for bleaching hardwoods.

Use of chlorine dioxide, sodium chlorate, and sodium chlorite is expanding in multistage processes for bleaching chemical pulps.

5. Outlook for 1952. Large expansions in the production of peroxides are scheduled for completion in 1952, to meet the increasing demands for these chemicals, particularly in the pulp and paper industry.

SULPHUR DIOXIDE

1. Availability. Brimstone, the element from which sulphur dioxide is produced is in an internationally critical condition. Government sources advise that the above-ground stocks have seriously been depleted due to consumption exceeding production. This being the case, NPA has issued order M-69 which restricts the use and burning of sulphur to the levels of 1950. This means that sulphur dioxide is available on the same basis in the same quantity as during 1950. However, the NPA has strictly ruled that sulphur dioxide may not be used to simply augment or replace sulphur. To the paper industry this means that you cannot purchase sulphur dioxide to conserve your own sulphur pile. However, where sulphur dioxide is technologically required it is available for use.

2. Price Changes. In the early days of 1951 there was a slight increase in some categories of the sulphur dioxide price schedule, particularly in the small cylinder class. This increase was necessary to adjust for increased labor, freight, and handling charges. As everyone knows, prices are Government controlled. However, due to the world shortage of sulphur and due to the fact that other more expensive sources of sulphur than brimstone may develop, it is possible that the general price level of elemental sulphur will be raised. If this occurs then sulphur dioxide prices will also have to be adjusted.

3. New Uses. New applications continue to develop for sulphur dioxide. The two newest and most principal developments are the use of sulphur dioxide as a grass silage preservative, and its use in the glass industry. Other applications are pending, and others are held in industrial confidence.

4. Substitutes. Again we must report that no substitute has been developed for sulphur dioxide. It appears quite impractical that one will ever be developed since this is a basic inorganic chemical. It is like trying to develop a substitute for sulphuric, hydrochloric, or nitric acids.

5. Outlook for 1952. This was covered under availability, but we can recapitulate and say that the world shortage of sulphur will require a careful allocation of sulphur dioxide for 1952. At this writing we feel certain that there will be adequate sulphur dioxide available to take care of all bona fide, regular users and also sufficient additional quantity to take care of new applications which will benefit the country's economy and particularly the defense economy. Early in the year, the world outlook on sulphur appeared dim for five years in the future; however, at the present writing, new and important sulphur domes have been located in Louisiana and Mexico and, while these will not immediately be available, it improves the sulphur outlook to the extent that instead of a 5-year shortage, we probably can consider a 2 or 3-year shortage.

ROSIN

In these columns, a year ago, it was stated that the rosin supply situation was much firmer than at any time in recent years. The same applies now.

During 1951 there was a decline in production of gum rosin but this was offset by increased production of wood rosin and by a reduced volume of sales. The statistical supply situation is therefore very much as it was a year ago, and the availability of rosin during the coming months will depend a great deal on whether demand improves over the 1951 level. It is very probable that there will be shortages of some grades of gum

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rosin, at times, and users who require certain grades and types of rosins may experience difficulty in supplying all their needs.

However, present indications are that any prospective shortage of gum rosin can be offset by production of wood rosin and tall oil rosin, and that there will be adequate supplies of the types of rosin required by the paper industry.

Presumably price controls will prevent any radical runaway of rosin prices during the year.

CASEIN

Although consumer demand was abnormally heavy through the first six months of 1951, casein supplies during this period were, nevertheless, adequate. Beginning in June, buying interest declined sharply and remained dull through the summer and fall months. As a result, stocks held by manufacturers and importers increased rapidly, and on August 31 were reported to be the highest for that date since 1942. Domestic casein production for the first eight months of 1951 totaled 17,500,000 pounds, a gain of 26% from a year earlier. Imports from Argentina have been substantially below 1950 volumes; but much heavier than normal quantities moving in from European countries have partially offset this reduction. Currently, production both in the United States and in Europe has declined seasonally, and reports from Argentina indicate flush production in that country will be well below normal because of drought conditions. If, as expected, demand again becomes active through the winter months, current surplus stocks will undoubtedly be absorbed rapidly.

During the first six months of 1951, prices generally were maintained at or near each seller's ceiling level and ranged from 39 to 41 cents per pound. The combined effect of heavy U. S. production and importation from Europe, together with limited consumer demand, was reflected in substantial price concessions during the third quarter of the year. Various grades of casein were offered with quotations ranging from approximately 29 cents per pound for French quality to 41 cents per pound for prime domestic material. Argentine casein prices remained firm at about 39 cents per pound during this period, but in mid-October, the Argentine Government relaxed export price controls and immediately following this action, prices declined to a level of $35^1/_2$ to 36 cents per pound. It is difficult to predict price trends for the balance of the year in view of uncertain business conditions. Currently, the market is soft but sensitive, and it is generally believed any important improvement in demand would immediately be reflected in higher prices.

As was the case one year ago, prospects for the coming year as regards price and availability are rather obscure pending decision by the U. S. Department of Agriculture on the 1952 dairy products support program. At the moment, there seems to be little reason to expect any substantial change from the current program and, therefore, assuming normal consumer demand, casein prices and availability should differ little from the pattern set during the first half of 1950.

GLUE

Although the supply of animal glue is not free enough to furnish unlimited quantities, enough of all grades and types is currently available to take care of actual needs of users.

The desire of the industry is a 6-day production week, but supply of raw materials for making animal glue limit production of most manufacturers to 5 days per week. With animal hides and bones in better supply increased production of raw materials is anticipated and during the early part of 1952, the animal glue industry hoped to resume a 6-day work week. This should improve supplies and allow it to take care of increased demands that may develop as a result of an accelerated defense production program.

Although Government statistics reveal inventories of animal glue in the hands of manufacturers at a near all-time low, practically all users have safe working stocks. Orderly deliveries are being made by producers and users are not under pressure to request emergency and rush shipments.

The world-wide demand for materials for the production of animal glue maintains a firm market, and prices for animal glues appear stabilized at present levels. Costs of producing animal glues have been advancing because of labor, coal, and freight cost increases which are major factors in producing animal glues, in addition to raw material costs. Manufacturers have absorbed increases during the past year but a continuance may oblige producers to increase selling prices.

As a result of animal glue being a product used some place in the manufacture of about everything that is made, demand, though spotty in some fields, is good and being an item used for the production of both civilian and war goods, an entirely free supply is not anticipated. Should a major defense production program be put into effect, allocation of animal glue might be necessary either by manufacturers or the Government. Users are thereby urged to maintain reasonable working inventories should the flow of deliveries be deterred for any unforeseen reason.

STARCH

1. Availability. Good.
2. Price Changes. Minor.
3. New Uses. None.
4. Substitutes. No new ones.
5. Outlook for 1952. Supply good, price stable.

ENZYMES

There have been no important changes in starch converting enzymes during the past year. Prices remain the same and the supply is ample to meet all normal demands.

ALUM

Commercial Alum. Due to the great activity in the paper industry alum has remained in tight supply during the year 1950 and is expected to continue tight during 1951. Furthermore, the sulphur shortage must be considered in future planning since it is indicated that production of alum will be permitted to continue only on the basis of 90% of 1950 production. Paper production in 1950 was at a lower rate than in 1951, therefore, the reduction is greater than indicated. No price changes have occurred or are expected.

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Iron-Free Alum. The availability situation on iron-free alum is very similar to that for commercial alum. It will continue to be affected by defense orders, particularly for the manufacture of Napalm used in fire bombs. The price has remained constant and is expected to continue. Some paper mills have investigated the use of aluminum chloride solutions, and although the cost is comparatively high, satisfactory sizing results have been obtained.

CLAY

American coating and filler clays are being produced in quantities ample for all needs. Demand, for machine-coating grades in particular, continues to increase slowly, and mining and beneficiating facilities are well able to care for it.

No changes in price of any standard grades of American papermaking clays have been announced. Freight rates, however, continue to rise, and many consumers pay more to the carriers for their clay than to the producers. Transportation costs of imported clays have also increased.

No substantial change in the position of clay as the papermaker's No. 1 pigment has been observed. Neither new applications nor competing materials have altered this picture appreciably.

The American clay industry can be depended upon to meet all needs quantitatively and to continue to improve both the quality and the uniformity of its product.

TITANIUM PIGMENTS

At this time, supply and demand are essentially in balance on titanium pigments. Titanium dioxide is still under allocation, but the amount of the monthly quota has been 100% of the normal base for the past several months, and it is possible that this may go somewhat higher. Titanium calcium pigment is now in free supply and probably will continue so.

At this time, there is no change in price.

Titanium pigments continue to be used for paper in both the beater and as coatings. There is some possibility that the new latex coatings formulated with titanium pigments may find a place in the coated board field.

Since last year's report, we have brought in some additional productive facilities and have further expansion under way, which we hope will make more titanium available in 1952. However, the maintenance of present tonnage or the bringing in of additional capacity will be dependent on the availability of certain critical raw materials.

ZINC SULPHIDE PIGMENTS

Improvement in the supply situation of zinc pigments is the important information at this time.

For those numerous uses where a higher filler content of the paper is permissible, and for coatings, for which it is well adapted, it would seem reasonable to predict that the supply of lithopone will be sufficient for all foreseeable demands in the absence of any governmental restrictions which might interfere with its availability. Lithopone is now selling for 7.90 cents per pound in carload lots.

Technically pure zinc sulphide is also in freer supply, and for those specialty uses where the paper industry continues to prefer this pigment, it will be available at 25.30 cents per pound.

A new use for fine particle size zinc oxide should be mentioned. It is now being used in conjunction with certain agents incorporated to improve wet strength in papers. This zinc oxide is available at 17.60 cents per pound.

DYESTUFFS

1. During the early part of the year, because of the large over-all demand for dyes, there was some delay in supplying dyes to the paper industry. In general, this did not seriously affect the production of colored paper. On the whole, most products were readily available.

2. No price changes of any importance occurred during this year.

3. No new uses of dyes were developed, as far as we know.

4. Tungstated tinting colors were replaced by molybdenum types due to restrictions on the use of tungsten.

5. The outlook for the coming year depends on business in general but it is believed that dyestuff consumption by the paper industry will be equal to 1951 or perhaps slightly lower.

SYNTHETIC RESINS

Part I

The year of 1951 witnessed a great increase in the demand for wet-strength resins by the paper industry. Shortages in early 1951 were felt but these were resolved during the year. In the case of urea-formaldehyde resins the supply situation became very good early in 1951 and it is continuing up to the present date. Melamine resins, on the other hand, were very short in supply during most of the year. Increased production facilities, however, have overcome this shortage and the months of November and December find melamine resins in good supply.

Melamine resins experienced no price changes during the year of 1951.

Several new urea-formaldehyde resins have appeared during 1951. Many of these are improvements on old-type resins and a few are new ones offered by additional producers having an interest in the field. Most of the new urea-formaldehyde resins are cationic liquid products. There has been an increased interest in tank car shipments of such resins and many mills are installing equipment to handle tank cars of the liquid products. The solids on such products vary from 30 to 40% for most of the prominent resins.

Military requirements for wet-strength papers greatly increased the demand for both melamine and urea resins during the year. The military end uses, such as V boxes and map papers, represented the major portion of the demand. The V-box requirements tapered off during the latter part of 1951, whereas the map grades held up fairly well. Civilian end-use requirements also increased as further civilian uses for wet-strength paper were developed.

The outlook for 1952 is naturally complicated by

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from end of June, while inventories of "other" waxes increased 7,560,000 pounds.

Comparison of wax stocks at end of July and August with Aug. 31, 1950, follows:

Petroleum Wax

(Thousands of Pounds)

	August, 1950	*July, 1951*	*August, 1951*
Microcrystalline	16,520	19,320	21,840
Fully refined	47,320	54,880	53,760
Other	87,920	105,000	122,830
Total	151,760	179,200	198,430

2. Price Changes. Refined paraffin wax price was stable through 1951. Scale wax down $^1/_2$ cent from early 1951. The market was further weakened by distress scale wax from the Pennsylvania refiners. Microcrystalline wax price was stable.

3. New Uses. The incorporation of butyl rubber in refined paraffin wax for use on cereal and similar type packaging has become widespread. The converter, and not the refiner, is adding the butyl rubber.

There were no notable new uses for scale wax.

Microcrystalline waxes came into their own in regard to compounded coatings for bread and frozen food wrap.

4. Substitutes. None.

5. Outlook for 1952. Prices existing in last quarter of 1951 for refined and scale wax should hold stable throughout the year 1952.

There should be a noticeable increase in the use of polyethylene-paraffin wax and polyethylene-microcrystalline wax blends if the polymer is removed from allocation. There is definite possibility of increased blending of these two materials on the part of the refiner.

Contributors to Report

Glue: R. Tutt, Jr., Vice-Chairman, Peter Cooper Corp., Gowanda, N. Y.
Caustic soda: R. L. Carr, Mathieson Chemical Corp., Baltimore, Md.
Soda ash: John Schuber, Solvay Div., Allied Chemical & Dye Corp., Syracuse, N. Y.
Lime: W. F. Swan, Standard Lime & Stone Co., Baltimore, Md.
Sulphur: D. B. Mason, Freeport Sulphur Co., New York, N. Y.
Sulphur dioxide: W. F. Luckenbach, Virginia Smelting Co., West Norfolk, Va.
Chlorine: R. W. Hooker, The Chlorine Institute, New York, N. Y.
Peroxides: J. S. Reichert, E. I. du Pont de Nemours & Co., Niagara Falls, N. Y.
Rosin-casein: J. C. Dieffenderfer, Hercules Powder Co., Wilmington, Del.
Alum: J. P. Bainbridge, Monsanto Chemical Co., Boston, Mass.
Starch: J. P. Strasser, Morningstar-Nicol, Inc., New York, N. Y.
Enzymes: F. H. Denham, R. T. Vanderbilt Co., New York, N. Y.
Dyestuffs: C. F. Schaumann, E. I. du Pont de Nemours & Co., Wilmington, Del.
Clay: J. H. Compton, Jr., Georgia Kaolin Co., Elizabeth, N. J.
Zinc sulphide: R. Davison, New Jersey Zinc Co., New York, N. Y.
Titanium: H. L. Jungmann, Titanium Pigment Corp., New York, N. Y.
Synthetic resin: L. Paul Saxer, Rohm & Haas Co., Philadelphia, Pa., and K. E. Youngchild, American Cyanamid Co., New York, N. Y.
Plasticizers: N. R. Pike, Nulomoline Co., New York, N. Y.
Bactericides: S. J. Buckman, Buckman Laboratories, Memphis, Tenn.
Wax: D. T. Jones, Atlantic Refining Co., Philadelphia, Pa.

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Developments in the Graphic Arts for 1951

ROBERT H. SIMMONS

THIS issue of developments in the graphic arts is, as in former years, prepared from abstracts and articles published in the technical and trade magazines. Very little information has been obtained directly from the inventors or manufacturers. Therefore, some of the information is meager and in many cases, where trade names are used, the actual chemical product has not been described.

PAPER

The advent of rust inhibiting packaging papers is an important development in papermaking for 1951. The papers are coated with the inhibitor crystals and the metal article wrapped and sealed in the paper. The vapors from the chemical penetrate to every crevice inside the package. This eliminates the use of grease and produces the article ready for use on breaking the seal. Robert C. Clark (*1*) reports that the period of protection depends upon the seriousness of the moisture conditions encountered. He lists four competing companies, each of which uses a different inhibitor formula. The *Aminco Laboratory News* for July, 1951, states that Shell Oil Co. (*2*) manufactures a "volatile corrosion inhibitor," and the *USI Chemical News* for May, 1951, states that dicyclohexyl ammonium nitrate, a white odorless powder which is slightly volatile, gives off a "mothball effect," preventing the entry of moisture and air.

The Tobey Color Card Co. (St. Louis, Mo.) has a machine capable of simultaneously coating any number of colors on a sheet of paper. The process permits the application of colors regardless of tone, range, or hue, next to one another without the possibility of overlapping or overrunning. Color stripes may be made of any width and they may be intermixed.

A test run of 4 tons of newsprint was made at Baie Comeau, Canada (*3*), in which radioactive iodine made it possible to follow the meshing and intertwining of the fibers, permitting a continuing study of solutions and substances coming together at any mixture state.

The action of potassium pyroantimonate ($K_4Sb_2O_6$) upon starch (*4*) in paper coating produces a water-resistant coating. The addition of 10% of the antimony salt, based on the starch, is added to the pigment and adhesive slurry immediately after they have been blended.

The finest glass fiber ever made has been produced by Glass Fibers, Inc., Toledo, Ohio (*5*). The fibers measure $^1/_{20}$ the thickness of a human hair. It has been felted to act as a filtering medium for submicron dust and, when impregnated with resins, can be made into glass paper for electrical insulation.

An instrument developed by M. Pfender (*6*) for measuring expansion in steel construction has been adapted to the measurement of dimensional stability in paper. Conditioned paper is placed between two glass plates equipped with bored holes into which fit a stationary and a movable foot. The expansion of the measured sample is magnified by a lever transmission recorded on a dial. This instrument has been tested by The Institute of Paper Chemistry.

The Hercules print tester is an instrument for checking pick resistance of paper. Roughly, the machine consists of an inking roller, a polished steel printing roller in parallel with a rubber-covered drive roller mounted on the same shaft, and an impression roller or cylinder. The impression cylinder has a means for mounting the paper sample which can be underlayed similar to printing press packing. The ink is placed upon the inking roller and distributed onto the printing roller. When the ink is uniformly distributed, the impression roller is released and by means of the driving roll makes an impression on the paper sample. The conditions of ink film, temperature, and humidity are very carefully controlled. The character or amount of pick can be estimated by observation.

Martin Hartmann (*7*) has emphasized the significant influence of the uniformity of beating of paper pulp on the ink-drying rate. In a previous article, he determined that starch sizing had a beneficial effect, but was unable to confirm this conclusion in later experiments. The degree of bleaching may leave residues which act as inhibitors in the drying of linseed oil.

The ANPA Research Laboratories, Technical Report No. 4, have been studying the feasibility of waterproofing newsprint so that the outside sheet of a newspaper will not disintegrate when it becomes rainsoaked. The outside sheet will act to protect the rest of the paper against moisture. They have tried Dri-Film, a product of General Electric Co., and find that a 1-second exposure to a 3% solution of Dri-Film greatly increases the water resistance of newsprint but that some other material is being sought due to certain objectionable chemical and physical properties of the Dri-Film.

Walter Perry (U. S. pat. 2,524,926)(Oct. 10, 1950) has an instrument which permits the viewing of a moving web without slowing down or stopping its motion. The stroboscopic effect of the instrument permits the studying of an individual cut or portion of the film while the press is still in motion.

Nathaniel Bishop (U. S. pat. 2,536,152) (Jan. 2, 1951) to Time, Inc., has an electronic register control whereby the movement of the web is controlled in relation to another moving web to permit register, pasting, and cutting.

The Institute of Paper Chemistry has developed a modification of the Chapman smoothness tester to permit observation of the surface smoothness of a sheet of paper under press pressures. The report states that a study is being made to find a thin transparent plastic film to place over the test sample to simulate printing ink.

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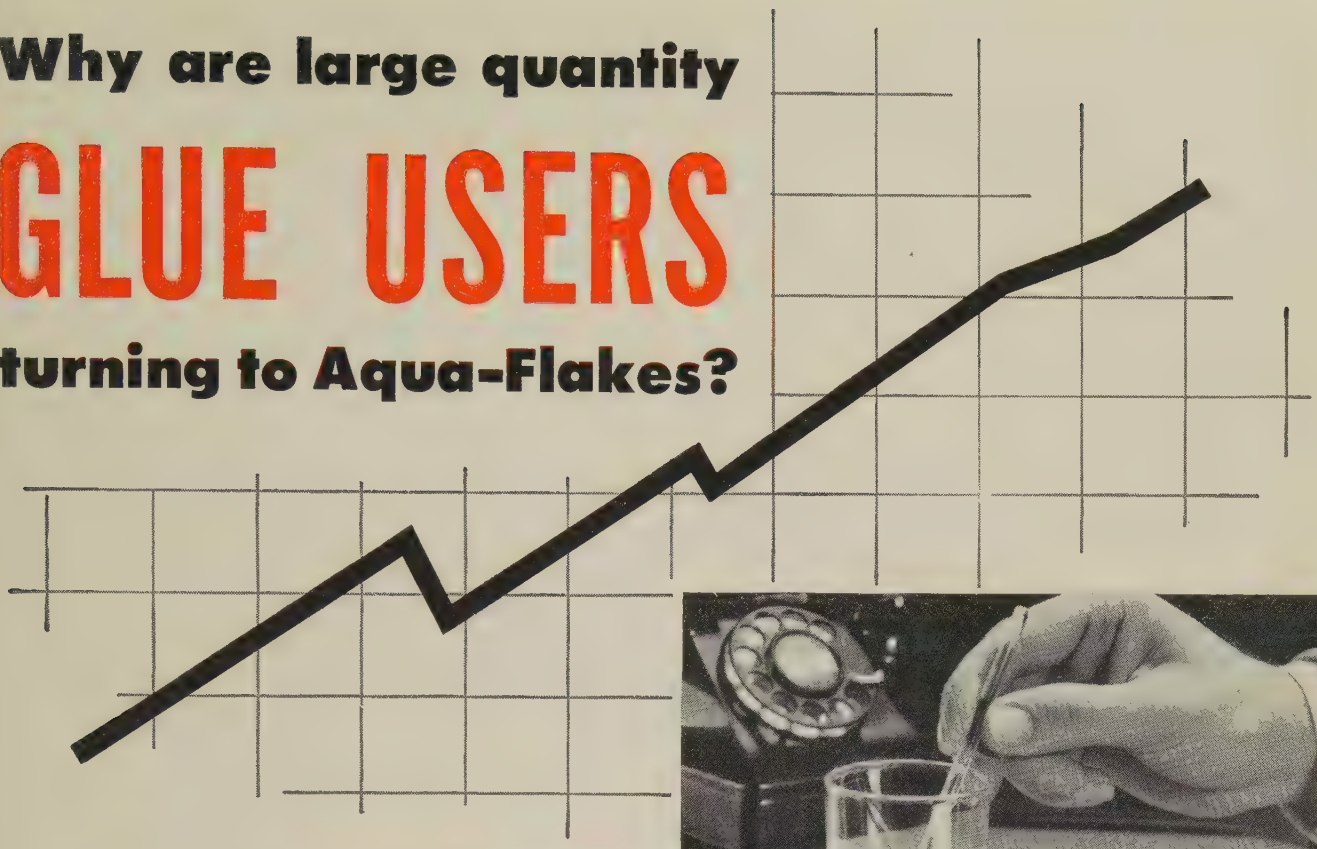

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The finest glass fiber ever made has been produced by Glass Fibers, Inc., Toledo, Ohio (*5*). The fibers measure $^1/_{20}$ the thickness of a human hair. It has been felted to act as a filtering medium for submicron dust and, when impregnated with resins, can be made into glass paper for electrical insulation.

An instrument developed by M. Pfender (*6*) for measuring expansion in steel construction has been adapted to the measurement of dimensional stability in paper. Conditioned paper is placed between two glass plates equipped with bored holes into which fit a stationary and a movable foot. The expansion of the measured sample is magnified by a lever transmission recorded on a dial. This instrument has been tested by The Institute of Paper Chemistry.

The Hercules print tester is an instrument for checking pick resistance of paper. Roughly, the machine consists of an inking roller, a polished steel printing roller in parallel with a rubber-covered drive roller mounted on the same shaft, and an impression roller or cylinder. The impression cylinder has a means for mounting the paper sample which can be underlayed similar to printing press packing. The ink is placed upon the inking roller and distributed onto the printing roller. When the ink is uniformly distributed, the impression roller is released and by means of the driving roll makes an impression on the paper sample. The conditions of ink film, temperature, and humidity are very carefully controlled. The character or amount of pick can be estimated by observation.

Martin Hartmann (*7*) has emphasized the significant influence of the uniformity of beating of paper pulp on the ink-drying rate. In a previous article, he determined that starch sizing had a beneficial effect, but was unable to confirm this conclusion in later experiments. The degree of bleaching may leave residues which act as inhibitors in the drying of linseed oil.

The ANPA Research Laboratories, Technical Report No. 4, have been studying the feasibility of waterproofing newsprint so that the outside sheet of a newspaper will not disintegrate when it becomes rainsoaked. The outside sheet will act to protect the rest of the paper against moisture. They have tried Dri-Film, a product of General Electric Co., and find that a 1-second exposure to a 3% solution of Dri-Film greatly increases the water resistance of newsprint but that some other material is being sought due to certain objectionable chemical and physical properties of the Dri-Film.

Walter Perry (U. S. pat. 2,524,926)(Oct. 10, 1950) has an instrument which permits the viewing of a moving web without slowing down or stopping its motion. The stroboscopic effect of the instrument permits the studying of an individual cut or portion of the film while the press is still in motion.

Nathaniel Bishop (U. S. pat. 2,536,152) (Jan. 2, 1951) to Time, Inc., has an electronic register control whereby the movement of the web is controlled in relation to another moving web to permit register, pasting, and cutting.

The Institute of Paper Chemistry has developed a modification of the Chapman smoothness tester to permit observation of the surface smoothness of a sheet of paper under press pressures. The report states that a study is being made to find a thin transparent plastic film to place over the test sample to simulate printing ink.

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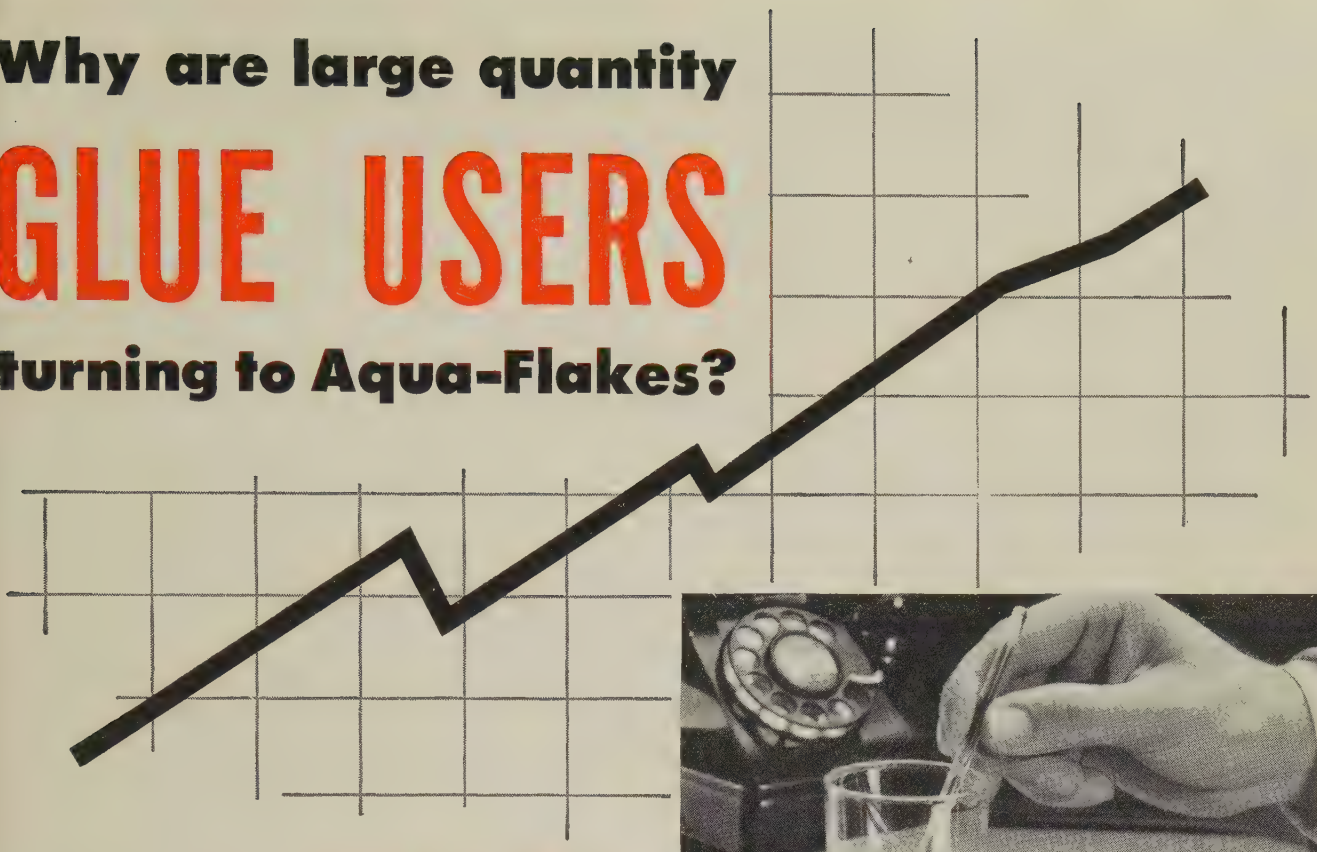

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U. S. pat. 2,508,045 (May 16, 1950), E. I. du Pont de Nemours and J. S. Seny have a moisture indicator for webs. Two conducting members are separated by the web. A condenser and a direct voltage source are connected in series with the two conducting members. The electrical resistance of the web controls the rate of charge of the condenser and there is an automatic means for discharging the condenser when it reaches a definite point. The condenser charges and discharges in cycle. The frequency of this cycle is a function of the moisture in the web.

An electronic hygrometer (*8*), consisting of gold leaf electrodes in the shape of interlocked combs, is mounted in plastic. The electrodes are coated with a thin layer of chemical salts. The current passing through the salts on the electrodes changes with the moisture content of the air. This gives a means of measuring the relative humidity directly without the need for psychrometric charts.

ANPA Research Bulletin No. 40 (Feb. 9, 1951) reports on a method for precise control in air conditioning where the temperature and relative humidity can be held constant or varied at will. The system provides dry air at normal atmospheric temperature with little or no refrigeration.

Industrial Materials Purchasers Co. is marketing an industrial humidifier which is complete, requiring no drains or steam but only a water feed. Humidification is accomplished by centrifugal action.

The Dryomatic Corp. has a portable moisture control or dehumidifying unit. It is classed as a three-channel, continuous adsorption dehumidifier. A single unit will handle 25,000 cu. ft. of air from − 40 to 100 °F. and can maintain as low as 15% relative humidity. There are models for 7000, 10,000, and 25,000 cu. ft.

PRINTING INKS

The American Chemical Society has set up a division to take care of printing inks. The new division is to be called "Paint, Plastics and Printing Ink Chemistry."

The ANPA Research Laboratories moved into their new quarters at Easton, Pa., in June, 1951.

Printing Industries of America, Inc. (*9*), have published a photoengraving specifications manual reproducing standard process colors. The colors were developed in cooperation with the technical committee of the National Association of Printing Ink Makers. The manual includes specifications for: tone density, black and white engravings, two-color engravings, four-color engravings, standard process colors, bleed pages, and metallic inks. The American Association of Advertising Agencies and The American Newspaper Publishers Association have adopted standard four-color comic ink specifications. The report contains specifications which should allow ink makers to duplicate the standard hues, trichromatic coefficients, dominant wavelength, and purity of the ink colors.

One obstacle to greater printing speed has been the time required for the ink to set. The development of heat-set inks permitted higher speeds, but the near-scorch temperatures used in drying the ink caused the paper to become brittle. A new formula, called a balanced ink (*10*), has been developed. A resin which is insoluble in either solvent alone of a two-component solvent but is soluble in the mixture becomes insoluble again if the balance of the solvent is upset. One of the solvents is an alcohol. When the ink is placed on paper, one of the solvents is removed by absorption and evaporation which causes the ink to set. Best results are obtained with the application of heat at a temperature of only about 15 to 20% of that of scorch-heat.

Leslie G. Luker in *Printer* for March-April, 1951 (*11*), gives practical recommendations for the use of inks to which perfumes have been added. He gives a list of perfume materials which can be tried in inks and a method for testing to calculate the required amount of perfume per pound of ink. The importance of temperature in the use of perfume is stressed.

Vincent A. Lauderman (U. S. pat. 2,536,555) (Jan. 2, 1951) has developed a water-base printing ink. The ink is composed of 100 parts by weight of pigment dispersed in a vehicle 0–40 parts of alkali dispersible protein, 3–100 parts of a natural resin, and urea 2–7 times the amount of protein. The pH of the finished ink will be 7.0 to 9.0.

India imports about 2,000,000 pounds of ink a year. It is reported that the oil extracted from cashew nut shells (*12*), mixed with allied resinols is used in making a local news ink which equals the best imported ink. Indian pat. 40,257, 8 parts by weight of carbon, plus 10 parts of cashew nut-shell oil, and 90 parts of mineral oil.

British pat. 589,218 has been assigned to Ford Motor Co., Ltd., for a penetrating marking ink. The patent gives a formula of 20% resin, 10% castor oil, 64% alcohol, 4% oil-soluble red dye, and 2% insoluble Victoria green dye. Durez 11696, an alcohol-soluble phenolic resin, is recommended. This ink penetrates the normal coating materials and resists the average solvent cleaners.

The Organic Products Co. (Irving, Tex.) also has a metal stamping ink which is noncorrosive but which has excellent adhesion to metals including aluminum, magnesium, and stainless steel. It is resistant to petroleum-type cleaning fluids, oils and greases, hydraulic oils, and chlorinated solvents. The ink does not affect the rubber stamp or the pad. It dries by evaporation leaving a dry, nonsmearing print.

An ink for polyethylene has been reported in *Chemical Engineering* 58, No. 2:230 (Feb., 1951). A 2:1 mix of alkathene (a polyethylene) and polyisobutylene is used as a film former. The polyisobutylene is dissolved in a mixture of equal amounts of tetrahydronaphthalene and trichloroethylene.

The cover for the January, 1951, *Reader's Digest* was printed with a new metallic printing ink, the basis for which was developed by the Bakelite Div. of Union Carbide & Carbon Corp. The vehicle contains vinylite resins which has an exceptional affinity for paper and gives a permanent, hard, high gloss surface to the dry ink.

The Technical Processes Div. of Colonial Alloys Co. has a new solvent, Soludiene, which evaporates in 0.26 the time of benzene. It may find a use in gravure inks.

The Chemical Div. of the Borden Co. has published a technical bulletin on Protovac caseins. These caseins are soluble in mixtures of alcohols or ketones with water. They give a low relative viscosity, and PV-412,

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when compounded in an overprint varnish, gives quick drying and flexible finish.

J. M. Schantz, Hercules Powder, Co., reports on rosin as a chemical. Polymerized rosin can be used in heat-set and gravure inks. It can be co-polymerized with other chemicals. An alcohol derived from rosin is finding a use in aniline inks to help them adhere to polyethylene plastics.

The General Mills, Inc., have Resinous Alcohol-8, which combines the properties of a plasticizer and a resin which will effectively plasticize nitrocellulose lacquer films and improves adhesive qualities. It is a mixture of mono, di, and tri-glycerides of rosin and fatty acids with a small number of free hydroxyl groups, and is a light-colored, viscous, noncrystallizing liquid.

Modiphant 345 (General Mills, Inc.) is a pentaerythritol ester of rosin, fatty acid, and maleic anhydride. It is a fast drying, oil-soluble alkyd resin which disperses rapidly in oil at low heat, giving a rapid drying varnish which produces a hard tough film with good color and is resistant to water and alkali.

Polyamides (Suspensoids) derived from soybean or vegetable oils, combined with ethylene diamine, act as a heat-sealing adhesive.

Edgar Brothers Co. have published a bulletin, "How to Extend White Hiding Pigments," in which they tell about water-fractionated, hydrous aluminum silicate, a fine particle size, inert white pigment with a soft texture. ASP-100 is not coated while ASP-1100 is stearate coated.

USI Chemical News of Jan., 1951, recommends zirconium silicate as a substitute for titanium dioxide. The report is on its use in cosmetics but the report mentions that the covering power is lower than titanium dioxide but better than zinc oxide.

Allyl starch (General Mills, Inc.) is finding use in aniline, rotogravure, steam-set, and tin printing inks. It can be used as a replacement for shellac. It is not soluble in aliphatic compounds.

Sherwin-Williams Co. has a new phthalocyanine blue pigment which is in the same color range as peacock blue, but is five times as strong as fugitive peacock blue. This new pigment has good chemical and light resistance.

The National Bureau of Standards (Research Paper 2116) has designed a new vibratory ball mill. The mill uses 3700 steel balls which collide at a rate of over 100,000 times per second. This mill produces a more uniform powder and is more efficient and easier to operate than previous devices. It is an experimental mill. Five grams of cotton were reduced in 30 minutes to particles 10 mu in diameter.

The T. J. Laird Equipment Corp. (Buffalo, N. Y.) has a kinetic dispersion mill, a noncolloid type which gives rapid dispersion of news, gravure, aniline, and carbon paper inks. The mill utilizes the principle of high speed acceleration of pigment agglomerates in a fluid carrier to perform dispersion. The kinetic energy imparted to the agglomerates is converted at the point of highest speed to work energy by a violent change in direction of the agglomerate motion. At this point, the mass is forced against a stator member in the dispersion head. Hydraulic turbulence caused by a drop in pressure and increase in velocity in the stator frame further disperses the broken agglomerates in the vehicle. An increase of color strength, as much as 15%, is claimed for certain formulations.

J. S. Gourlay and P. S. Williams in *Paint Manufacture* 21, No. 3:93 (1951) state that the method of milling has an effect on the flow of the dispersion. A 30% zinc oxide was ground in linseed varnish in a ball mill and a three-roller mill. The yield value of the ball mill preparation was greater than that in the three-roller mill. It was noted that the removal of a small amount of water from the mixture reduced the yield value. The addition of oleic acid increased the yield and apparent viscosity. The addition of zinc naphthenate did not affect the viscosity, but did reduce the yield value.

"Enersols" (stearic acids), Emery Industries (Cincinnati, Ohio) state that these acids facilitate grinding of metallic pigments and powders. The Enersols give excellent leafing characteristics of the metallic powders and make them oxidation-resistant and free flowing.

Spencer Kellog & Sons (Buffalo, N. Y.) have developed (Kelcastol), a substitute for castor oil. The oil, soluble in ethyl and methyl alcohol, has the same viscosity color and drying properties, and costs less.

Esters of xylitol with linseed and soybean fatty acids (*13*) have been prepared as possible drying oils. The report states that an average of four of the five hydroxyl groups are esterified and the fifth is lost by dehydration. The method has not been perfected as yet.

Low molecular diene polymers obtained from the by-products of synthetic rubber are suggested as a linseed oil substitute. The method was reported in *Poligraf Proizvodstve* No. 9:29–30 (1950), Russian. The polydiene dries in 6 to 8 days. The addition of 1.5 to 3.0% manganese drier produces drying in 10 to 13 hours. The crude can be further polymerized by heating at 150°F. with driers to the desired viscosity. If a light color is desired, the drier is not added until thermal polymerization is completed. Lithographic blankets are only slightly affected when immersed in the oil.

The Gates Engineering Co. has GACO Vinyl coating which can be applied by roller or spray equipment similar to lacquers and varnishes. It gives a high gloss finish with a permanent whiteness impervious to beverages, fats, oils, and grease. When coated on paper the quality of the paper remains unchanged.

Hurst Plastics of Los Angeles (*14*) are marketing several plastic varnishes which are compatible with regular varnishes. When added to inks, it keeps them open. They give gloss, grease and moisture resistance, good adhesion with a hard top, and scratchproof drying. Hurst Plastics also have a drier substitute for cobalt which is scratchproof, and an aqueous solution for cleaning engravings, called "Dynamite."

American Cyanamid Co. reports on modified sodium polyacrylates which are water-soluble, anionic colloids of a clear straw color.

DRYING OF INKS

Considerable research is being done on new methods to obtain rapid drying or instaneous drying of inks.

Armour Institute of Technology have developed a new method of drying ink which will cause hardening

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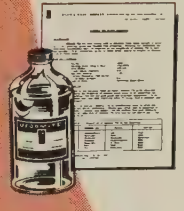

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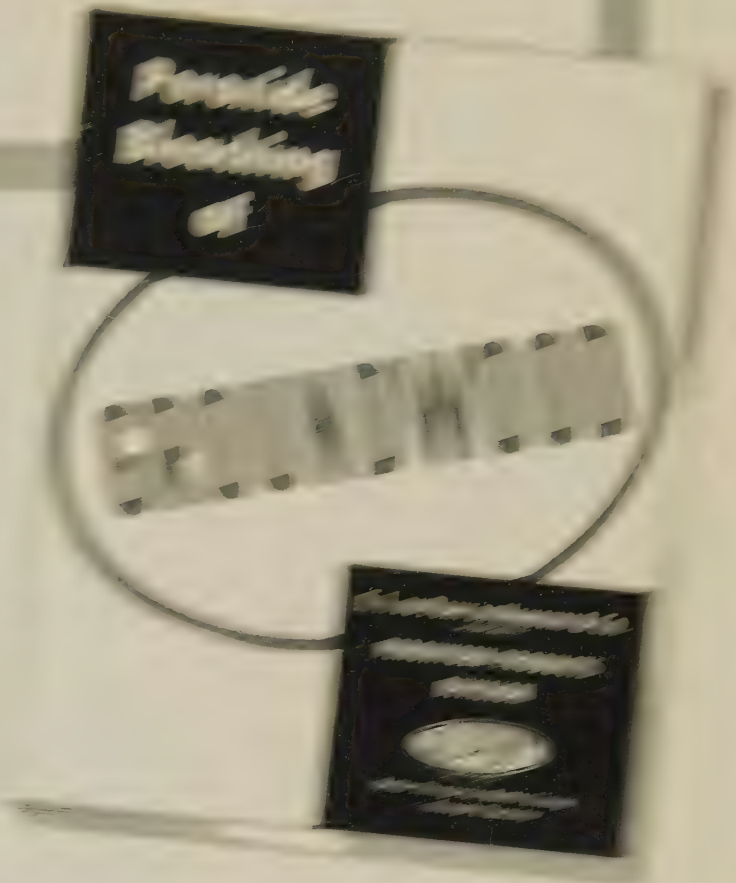

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PEROXIDES

arc lights during color separation. Highlighting can be accomplished by painting on the Fluorostop with a special paint.

The Army Signal Corps at Ft. Monmouth, N. J. (*22*), has found that they can process films in one tenth the time and prints in one half the time necessary under normal procedures. It is not necessary to wash the photographic materials. A special formula of Amidol developer is used together with a stop bath and stabilizer solution. A water solution of thiourea converts the unexposed silver compounds into light-insensitive form. Resistent photographic paper reduces the drying time.

The Haloid Co. has a new photosensitive paper negative called Transaloid. The base is a water-resistant, transparent plasticized paper stock coated with a transparent negative material which is nonstripping, nonhalation, and orthochromatic. Lithaloid film has an extremely contrasty emulsion which produces maximum density with unusual orthochromatic sensitivity while Lithaloid paper produces a nonstripping negative for producing line negatives and positives.

The Andrew Jeri Co., Inc., has a protective masking material for use in photoengraving, lithography, and rotogravure. The material is a red liquid plastic which dries to form a temporary protective film, impervious to dyes, acids, and alkalies, and is also moisture-resistant. It can be used on nonporous surfaces and, when dry, can be easily removed by peeling off.

The Directo Polished Litho Film is produced by the Direct Reproduction Corp. (Brooklyn, N. Y.). The film is polished smooth on both sides. The advantages of this film are that it gives clearer transparencies, perfect register, and has a dimensionally stable vinyl base for easy handling.

The Armour Research Foundation was directed by the U. S. Signal Corps to develop a film base having good dimensional stability, optical clarity, low moisture absorption, constancy of composition, good aging qualities and ease of fabrication, over the entire range of temperature from − 65 to 140°F.

The Armour Research Foundation Bulletin PB 102 294 Research Directed Toward Development of Acclimated Silver Halide Film describes several cellulose film bases which meet the above requirements together with the methods of testing.

"Transparent Proofs from Type Forms" is the subject of Bulletin C-3 published jointly by the U. S. Government Printing Office and Printing Industries of America, Inc. The bulletin describes the methods for preparation of the proofs, press procedures, drying of inks, inking of the press, makeready, and retouching of proofs. Three formulas for the ink in red, black, and white are given. The proofs can be handled as soon as they are pulled from the proof press.

Herman R. Freund and Fritz Stadelmann have been awarded U. S. pat. 2,552,881 (May 15, 1951) for a photographic-type composing machine. The mechanical features seem to be the new characteristics of the machine.

Multi-Ad Services, Inc., have a Headliner Photocomposing Machine. The characters are selected on a dial and contact prints made on a special plasticized photographic paper. To achieve justification, double typing is necessary. Proportional letter spacing is accomplished by an arrangements of slots cut into the edge of the Typemaster or font.

Wm. R. Butler (Forest Park, Ill.) has an improved carbon attachment which can be changed from one typewriter to another. The attachment permits sharp, black text matter for photo offset. Typing is best done on 25% rag content ledger. It can also be used for typing on direct metal or paper plates.

Varigraph Co., Inc., has a lettering device which measures 7 by 7 inches and slides smoothly along a rule or straight edge. A lettering pen on the upper left corner is moved by a stylus on the lower right corner. The stylus moves in an insertable templet. Control knobs determine the height and width of letters. Settings can be changed from 0.15 to 0.75 inch.

The Magniscriber (Crane Rudolf Co., Cincinnati, Ohio) combines a magnifying glass, rule, and scriber in one instrument. It is designed to eliminate inaccurate cutting of register marks on film.

The Enley Products Co., Inc., has an inexpensive water demineralizer which can be attached to the regular water tap. One cartridge, it is claimed, will produce 120 gal. of chemically pure water, equivalent to triple distilled water. The resins in the cartridge change from blue to yellow as they become exhausted. The cartridge is replaceable and fiberglass filters help to trap physical impurities.

The Curtis Laboratories (Los Angeles, Calif.) have built the Curtis Color Analyst. The instrument is a one-shot color camera in reverse. It creates a color image out of black and white. A full color image is photographed using a one-shot camera to produce the three negatives for color separation. Enlarged bromide prints are made of each negative. These are placed in the Color Analyst and the viewer sees the image in full color. Any color correction can be made by adjusting the prints or by retouching. The instrument relieves the need for proofing as prints of the plates can be reassembled in the Color Analyst for comparison.

The Pittsburgh Plate Glass Co. (Allentown Warehouse) has a water-white printing frame glass available. The ANPA Research Laboratories have investigated this glass and find that it permits a 50% reduction in the printing time necessary to lay down an image on metal.

Microtonics lights (*23*) (a combination of small diameter fluorescent tubes with scientifically designed reflectors). By a proper selection of tubes, a light source which matches the sensitivity of the film emulsion, reduces exposure time. A proper combination of tubes and colors permit color separation without filters, using only a one-piece plastic compensating filter.

LITHOGRAPHY

James Finno has received a U. S. pat. 2,561,353 (July 24, 1951) on a lithographic printing plate composed of an unbacked, single-ply, un-sized sheet of uncalendered amyloid parchment paper having a minutely fibrous, fine grain surface characterized by low gloss and low smoothness values. The fountain solution used as an ink repellent is glycerine, sodium sulphate, boric acid, and gum acacia in water.

Keuffel & Esser Co. is selling presensitized plates in

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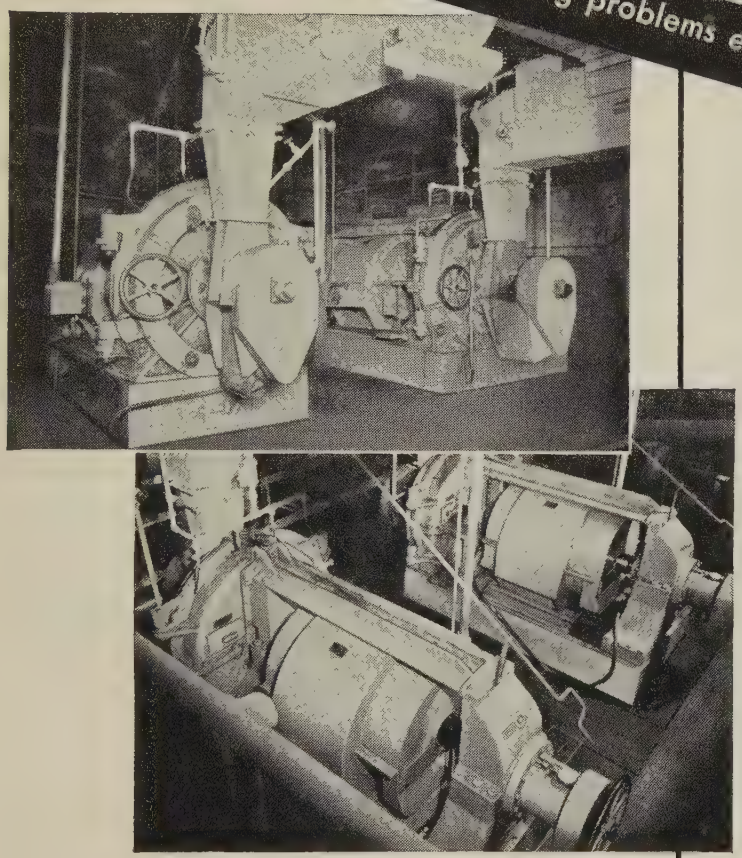

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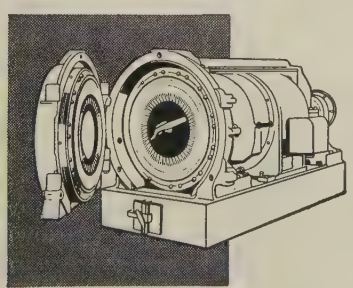

SPROUT-WALDRON

PULP REFINERS

194

sizes up to 25½ by 36 inches. The plates are specially prepared cellulose film backed by a water-resistant paper. The plates are taken from the package, exposed, developed, and attached to the press (90 seconds from exposure to press).

Minnesota Mining and Manufacturing Co. has a presensitized aluminum plate for small offset presses. The plate is 0.005 inch thick and will reproduce up to 300-line screen. It takes only 5 minutes from package to press.

Ektalith (Eastman Kodak Co.) cellulose acetate plates are made by hydrolozing the acetate to cellulose. The plates are backed by metal to produce dimensional stability. The film is sensitized with bichromate solution, exposed, and swabbed with an alkali solution which may contain an oxidizing agent. The plate is then neutralized with an acid solution and rinsed with water. It is capable of producing 75,000 impressions in line and 40,000 impressions in halftone. It is capable of use in color reproduction.

R. B. Mason (U. S. pat. 2,507,314) (May 9, 1950) has a method of producing an aluminum surface to produce a uniform matte surface by alternately treating with an alkali metal fluoride and a suitable acid. Repeated treatment produces a progressively rougher surface.

B. F. Terry (U. S. pat. 2,494,729) (Jan. 17, 1950) has a method of treating commercial aluminum plates with a 6% solution of disodium phosphate at 80 to 95 °C. for at least 10 minutes and then washing with water. This treatment prevents the formation of spots and defects due to the emulsion coating used in lithography from reacting with the defects in the plate surface which cause the formation of gas.

Charles Edmund Meulendyke (U. S. pat. 2,556,625) (June 12, 1951) has developed a solution for etching aluminum. The solution contains cupric chloride, glycerin and orthophosphoric acid.

Thomas C. Atwell and William C. Stone (*24*) have reported on a method for cleaning litho plates prior to regraining. The plates are scrubbed, using a chemical to remove old work and then treated with an abrasive, rescrubbed and finally washed. By this pretreatment, the graining time can be cut approximately 50%.

Otto E. Zahn (U. S. pat. 2,532,136) (Nov. 28,1951) has designed a method for graining litho plates using a centrifugal blast of wet slurry. The blasting wheel is horizontal with radial blades and an open center through which the slurry is fed. The plate is held in an elevator cage which moves up and down.

The Key-Rite Dial System (Aids Development Co.) aids the operator in adjusting the ink fountain with micrometer accuracy. It is claimed that the system permits faster makeready on solids and on reruns if records are kept of the fountain setting. The system produces less wear on the fountain blade and roller and quicker correlation of the key setting with the OK press sheet.

There are three references to spray devices for dampening offset presses. The Dutch report on a spray-nipple device (*25*). British pat. 649,216 uses an oblong box with a longitudinal slot through which atomized water is applied to the press, and Horace Edwin Harsden (U. S. pat. 2,543,663) (Feb. 27, 1951) calls for a similar device which forces air and water through jets onto the width of the plate.

Innis Speiden & Co., Inc., have developed several Iscolized gums which include arabic and tragacanth which are treated to give ready dispersion and eliminate presoaking. The treatment does not change the viscosity of the solution.

Minnesota Mining & Manufacturing Co. has a new masking tape for offset. It is Scotch brand lithographers tape. The tape has high opacity and is free from pinholes. It will adhere readily to negatives and photographs and can be used to mask imperfections, lay straight lines, and edge negatives.

Charles H. Van Dusen, Jr., has been awarded U. S. pat. 2,545,125 (March 13, 1951) for an image-forming material consisting of a solution of nigrosene base dye in tricresyl phosphate glycol mono-laurate containing stearic acid in an amount of from 2 to 4% of the composition by weight.

Van Dusen (*26*) has also described a means of offset duplicating in which the ink and fountain solution are fed to the plate through the same roller train from two different fountains. Although the entire train of rollers are covered with ink, there seems to be no emulsification present. The water seems to cover the ink film and, when the form roller contacts the image area, the water is forced out and the ink deposited but, when the form roller contacts an unimaged area, the water deposits on the surface keeping it free of ink.

Russell G. Thompson (U. S. pat. 2,529,978) (Nov. 14, 1950) has a facsimile copying apparatus which will record in a copy, a montage of different originals. The apparatus will arrange into a single picture a number of different portions of an original or several areas of various copies.

Minnesota Mining & Manufacturing Co. has an ultraviolet-sensitive coating material which, when coated on an aluminum plate, becomes water repellent on exposure to light. The unexposed part is water receptive and a litho plate made from this combination will give 20,000 to 30,000 impressions.

TYPOGRAPHIC PRINTING

William J. Hooper (U. S. pat. 2,558,900 and 2,558,-901) (July 3, 1951) has an electrostatic method and apparatus for printing. The method uses only a very slight pressure.

W. G. Montgomery (*27*) has designed a flatbed press which is claimed to be the fastest flatbed press in the world. The type bed and cylinders are synchronized at all times, assuring hairline register. The speed is 8000 impressions per hour with 16,000 on a two-color run. The inking system is designed for a powerful distribution and each unit has three form rollers. The feeder and delivery piles are both of the same depth, 45 inches, reducing the number of stops for loading and unloading. Both piles swing away from the press and the conveyor raises to permit easy access to the press parts.

The Printing Plate Supply Co. has the Proofmaster, a curved plate proof press. The press has interchangeable plate cylinders to accomodate different sized plates. The use of this press speeds up operations by proofing for accuracy and registration, reducing down-time on the printing press. The proof press has a retractable inking unit and impression cylinder and fast lock-up

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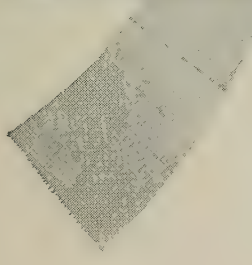

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device to permit easy and rapid exchange of plate cylinders and plates.

A. G. Arend reports on the effect of overheating zinc plates (*Photoengravers Monthly*, 57, No. 682: 301–302, (Oct., 1950)). A temperature of 250°F. is required for the burning in of dragon's blood or etching powder. Large grains will not form during normal variations in the length of plate heating at this temperature. An exposure to 350°F. for only a short period will increase the grain size several times normal.

General Plate Makers Supply Co. (Chicago, Ill.) have Scherer's ready-mixed hot top enamel. This enamel gives a tough, stable top which is unaffected by temperature changes or weather conditions. The exposure time is always uniform and no pinholes or lifts occur during etching. This enamel gives a cleaner scum-free print and is suited for use in electric etchers.

LePage's, Inc., claim to have the first humidity-proof coating solution on the market. The affinity of their hardener for this coating is so powerful that long press runs can be obtained from plates made using this combination. The solutions can be used in the regular procedure of platemaking.

General Plate Makers Supply Co. also has a new Cold Top Developing Tank which guarantees a crystal-clear solution at all times. A circulating pump forces the developer through a filter at the rate of 1 g.p.m. The temperature of the solution is controlled thermostatically and gives uniform development.

Mergenthaler Linotype Co. has a Wide Range line of linotypes. They are suited to extreme and diversified composition. The magazines are 35% wider than standard and can accomodate large display faces as well as text-size matrices. Electrical safety guards prevent shifting magazines until all matrices are distributed. There is similar control over the channels. Two green lights give the all-clear signal, but the locking devices remain in place until all is ready for shifting.

Vandercook & Sons, Inc. (Chicago, Ill.), have a new plate and backing sheet. The backing plate is cast from metal in a stereotype mold containing a grooved line pattern. Plates are adhered to the backing metal, using thermosetting plastic film under heat and pressure. The grooved plate permits gases to leak out from under the plate during mounting. This insures complete contact across the plate and backing. The plastic film does not change in thickness under mounting conditions. Extra thicknesses of film can be added under solids and highlights can be relieved. To remove plates from backing, soak in methylethyl ketone.

Photoelectric halftone reproductions (British pat. 643,330), Etablissements Edouard Belin, are produced by scanning the original photoelectrically. The amplifier output controls the movement of a galvanometer, the angle of deflection being proportioned to the density of the object scanned. A pencil of light of rectangular cross section is reflected from the galvanometer onto a rotating opaque disk containing a number of rings of radial slots of constant pitch. The light beam moves radially across this disk through a triangular aperture so that the transmitted pencil consists of a series of light pulses, in which the pulse rate and the pulse-space ratio are related to the original density. The pulses are collected by a photocell and amplified. This current may be used to print a halftone image photographically or to control an engraving tool to make a halftone block directly.

New stylus halftones are prepared on the Fairchild engraver, a product of the Fairchild Instrument Corp. (*28*). The instrument consists of a scanning head and an engraving stylus. The two units are mounted on a lathe-type base and the movement of both are synchronized with matching gears and thread pitch. The stylus is heated and burns or melts square dots in the plastic film which is 0.003-inch thick. The mechanism is set to control the number of punches which the stylus makes per inch. The finished film can be mounted on a metal base or a stereotype plate, using a double adhesive. The ANPA Research Laboratories have studied the Fairchild engraver and a number of the members of the association are using it in production.

The D-Y Dry Spray process (Dunaway-Yahnke Co., Philadelphia, Pa.) is a nontoxic powder highly soluble in ink. It is edible, nonabrasive, and nonclumping, resulting in perfectly smooth glossy or varnished sheets. Press loads as high as 1950 sheets can be run without danger of offset.

The plastic stereo molding blanket, a product of the ANPA Research, produces a dimensional gain of measurement across the width of the page without changing the length wise measurement. This factor in the use of the molding blanket has permitted a saving of 1 inch in the width of the mold so that the width of the web could be cut by 1 inch, resulting in a great saving in newsprint paper.

Oscar C. Roesen and Charles L. Richards (U. S. pat. 2,531,647) (Nov. 28, 1950) have designed a means of producing pockets in the underside of a stereotype plate (semicylindrical) so that the plate is held under tension on the cylinder rather than by compression as at present.

Luface (Fribourg, Switzerland) has a bi-metallic engraving material which, when used on a special plate (nickel-plated upon a steel plate to the proper thickness) gives rapid etching. The plate is treated with cold-top enamel and printed in the normal manner. The plate is then dipped in the etching material for 10 seconds. It is claimed that the etch does not undercut the dots due to the fact that it etches straight down until stopped by the steel plate. Six million copies can be printed from one plate.

In preparing electrotype shells for backing-up, it has been the general practice to sweat tin foil onto the back of the electrotype shell. This permits the backing metal to make a tight joint with the copper shell. With the shortage of tin, the Government Printing Office has developed a method for electroplating a lead-tin alloy onto the back of the copper shell which permits a good adhesion to the backing metal and saves from 50 to 75% of the tin formerly used.

The deposition of lead and tin is not difficult since certain solutions of the two metals have nearly the same potential. The solutions are readily available as "concentrates." Different compositions of the deposit can be obtained by varying the proportions of the concentrates, using alloy anodes or separate anodes of tin and lead.

Day-Glo colors are finding considerable application in the graphic arts. The first use of these colors was

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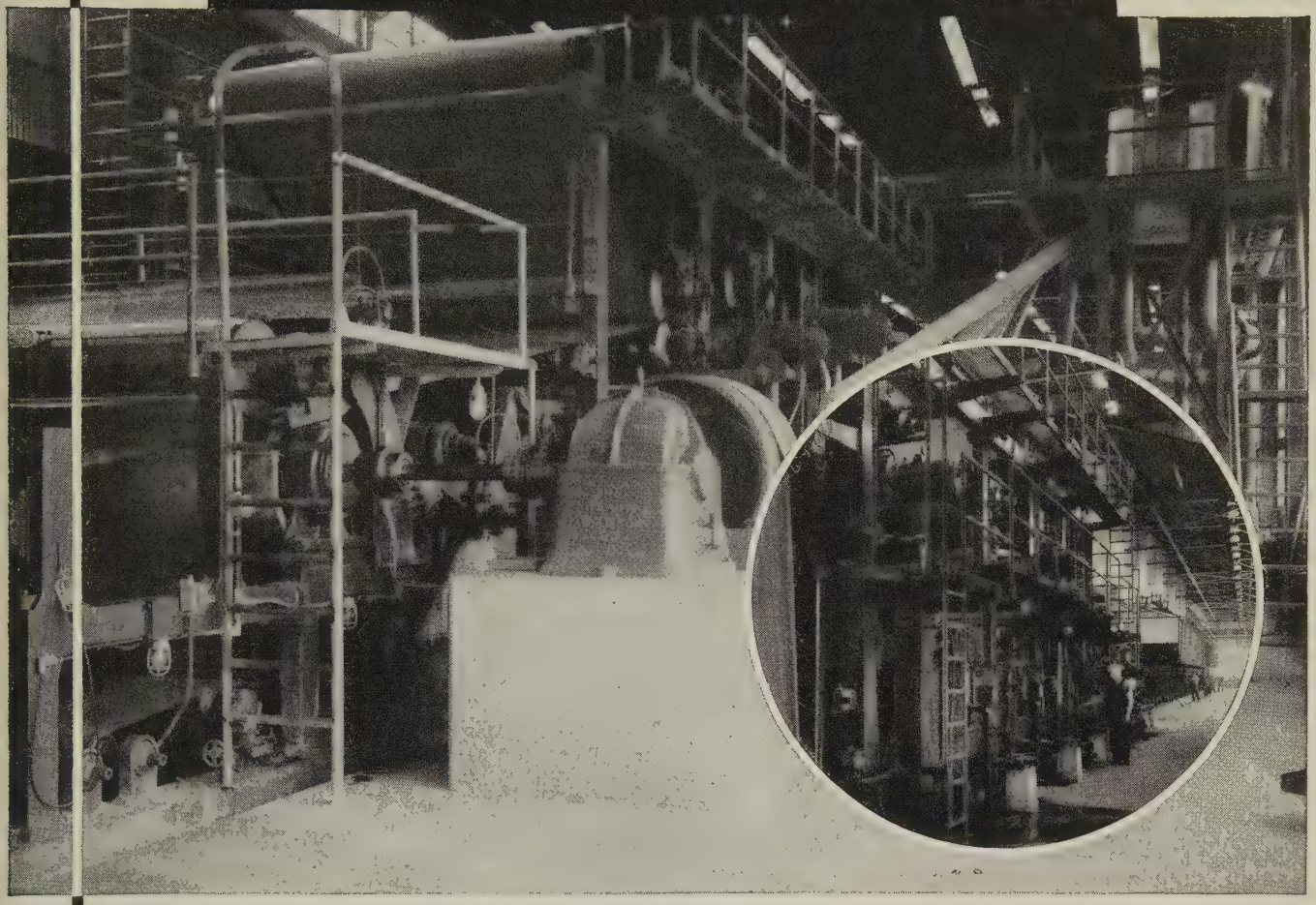

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in silk-screen printing. Recently, the I. S. Berlin Press printed 100,000—26 by 65—posters for General Food Corp. The nonfluorescent colors were lithographed on a four-color press. The entire sheet was then coated with spirit varnish. The sheet was then sized by printing on a lithographic press connected with a modified bronzer and the Day-Glo pigments were applied.

Fred'k H. Levey Co. has developed a Day-Glo gravure ink. This ink is rub- and scratchproof.

The Day-Glo pigments are being used by the Crocker, Burbank & Co. Ass'n. to coat papers. Dennison, Inc., has added these papers to their list of gummed papers. Kleen-Stik Products, Inc., are to use them in moistureless self-sticking adhesive labels.

There are five colors: neon red, fire orange, saturn yellow, arc yellow, and signal green. The printed results are not too permanent to light. The silk-screen inks are good for 30 days in direct light. The bronzed inks are good for 7 days in direct light or 14 in indirect light. The inks applied by gravure are good for 8 days in direct daylight and 3 months inside.

SILK SCREEN

The silk-screen process of reproduction is advancing rapidly. Robert Foster, in the *American Printer*, 132, No. 6: 46–47 (June, 1951) has reported on "Silk Screen Goes Mechanized." The report states that the inks, together with the stencils, stencil frames, and drying equipment have been greatly improved. New synthetic resin inks dry with forced ventilation in 12 minutes and the use of heat or infrared driers can reduce the drying time to 45–60 seconds, eliminating the need for drying racks. Photographic film screens are replacing the hand-cut films. Presses can now print from 450 to 1200 impressions per hour.

The Naz-Dar Co. (Chicago, Ill.) has a new solvent photographic silk-screen plates. The solvent removes the gelatin film from the photographic plate. The silk need not be removed from the frame since the solvent completely dissolves the film in a few hours. The solvent then washes off with clear water, leaving the silk ready for reuse. Since the solvent works without attention or scrubbing, labor time is saved and the silk lasts longer.

Devoe & Raynolds Co. has No. 640 overprint varnish for silk screen prints. This varnish dries to touch in 2 hours and hard in 6 hours. The sheets can be stacked after drying overnight. The varnish is formulated with an alkyd resin which gives an exceptionally high gloss.

MISCELLANEOUS DUPLICATING METHODS

Alexander Murray (U. S. pat. 2,503,759) (April 11, 1950) has a method called Evapograph. The method consists of coating onto a two-tone negative image formed of a material which adsorbs infrared radiation and converts it into heat, a layer of pigment containing ink which is not fluid enough to flow, but part of which ink will volatilize under the infrared radiation and is fusible and transferable when fusing. The negative is uniformly radiated with infrared of sufficient intensity that it evaporates and fuses all the ink on the infrared adsorbing areas without changing the ink in the other areas. A supporting member is then placed against the negative and a positive image is left upon the supporting member.

Alexander Murray (U. S. pat. 2,556,550) (June 12, 1951) has also developed another unique method for printing. It is classed as a heat-sensitive printing element in which a line of capillaries are in juxtaposition in a solid block. Each capillary is connected with a fluid-filled cell. Illuminating a line of a negative over the cells creates heat which causes the cells to emit ink which is received upon an absorptive surface.

The U. S. Air Force is using Xerography to enlarge microfilm drawings. Ditto, Inc., has produced an enlarged spirit duplicator to replace the gelatin pad in reproducing maps. The new machine will give more copies from an original master than formerly obtained from the gelatin pad.

A reproduction process, Perma-Stat (Trans-Gel Products, Inc.) consists in coating a plate with a stabilized bichromated gelatin. The coating is only sensitive to ultraviolet rays of a carbon arc or sun lamp, and can be handled in ordinary daylight or fluorescent light. After exposure, the plate is dipped in a dye solution of the desired color and given a quick rinse in water. Any number of colors may be registered on the plate. The emulsion is extremely resistant.

Remington Rand, Inc., are marketing Portograph paper which will give positive photocopy by either transmitted or reflected light.

Minnesota Mining & Manufacturing Co. has a heat-sensitive (infrared) duplicating paper. It is composed of a black backing coated with a white chemical composition which, on exposure, absorbs heat from the light and melts, producing a transparent opening with a black background.

BINDERY OPERATIONS

The Triangle Package Machinery Co. has a machine called the Triangle Visco-Mat which automatically converts dry adhesive into ready-to-use liquid glue. Dry glue or adhesive is put into the hopper of the machine, the dial is set for the desired viscosity, and the machine automatically measures the water and glue to make the proper viscosity. The manufacture of liquid adhesives by this machine saves floor space by substituting bags of dry adhesive for drums of liquid adhesive. There are no batches of adhesive wasted due to incrustation or lumpy mixtures. The manufacturer does not have to pay for shipping water.

High-grade animal glues are used in bookbinding and in the manufacture of composition press rollers. The Government Printing Office has found a rabbit glue, extracted by a fur processor, from rabbit skins. This glue compares favorably with cattle hide glue.

	Cattle hide glue	*Rabbit skin glue*
Gel strength (grams)	420	444
Viscosity (millipoises)	140	136
pH value	6.5	5.2
Foam (millimeters)	24.5	11 (lower value indicates less foaming)
Mesh	8	8

Rabbit glue performed in operation fully as well as the cattle hide glue.

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A new plastic pressure-sensitive tape called Acetate Film Tape, has been placed on the market. The resinous adhesive does not become soft or discolor on aging. The tape does not require a glassine or cloth facing sheet and is ready for use. The tape will withstand a temperature of 100°C. for a period of 168 hours without discoloration when attached to a paper and there is no visible penetration of the adhesive.

A low tack paper masking tape, No. 210 Masking Tape, can be used when it is necessary to remove the tape from paper surfaces without injuring the surface. Such a tape is extremely useful in preparing copy for photographing where the originals must not be injured. A similar tape, No. 250, can also be used for multiple additions where the same section of tape is reused several times.

The Polymer Industries, Inc. (Astoria, N. Y.), are selling Pylene resin adhesives available in powder, prepolymer liquids, or solvent solution form. The material is packaged in one package with a catalyst incorporated or in two parts to be mixed prior to use. Some of these resins can be polymerized without heat while others can only be polymerized with heat. These resins are resistant to solvents, chemicals, abrasion, and heat.

The Paasche Airbrush Co. (Chicago, Ill.) is producing a book cover lacquering unit (Type F50-SL) which is composed of two parts. The unit will apply two coats of lacquer on each cover or apply two colors to each cover. There is a short drying space between the two applications and the unit operates automatically. It will take covers up to 24 inches wide and will lacquer 10,000 sq. ft. per hour.

Wire-O Corp. has a round cornering machine which will cut two corners at one time, cutting the operation time in half. The operator can feed books up to $3^1/_2$ inches thick to the back guide. A side guide puts the book in position and holds it in place while the cut is made. Adjustments can be quickly made for any size from 4 to 18 inches in length. The machine can be set to make a single cut on larger sheets.

Engineering Products Co. has an Epco portable turntable for handling rolls and drums. The piece weighs only 28 pounds, lies flat on the floor and will sustain loads up to 10,000 pounds. It operates on ball bearings and is built of alloy steel.

The ANPA Research Laboratories made a study of mechanizing the mailroom of a newspaper office. The study induced the introduction of the Sheridan stuffing machine in a number of these offices. The reports state that one machine can stuff 11,000 newspapers in an hour.

MISCELLANEOUS

There are a number of items which apply to the graphic arts, but which do not fall into any one category. Recently, the Gold Seal Co. (Bismark, N. D.) publicized "Snowy" perborate bleach. This item of information is not new, but the perborates seem to be finding increased application as a bleaching agent.

The Southern Regional Research Laboratory, Department of Agriculture, in cooperation with Crown Zellerbach Corp., are working on the production of norconidendrin, a demethylated derivative of conidendrin which is extracted from the waste liquor of western hemlock pulping. The norconidendrin acts to increase the shelf life of vegetable oils and may find a use in wax paper coatings.

Hanson Van Winkle Munning (Matawan, N. J.) has developed BSZ-300, an additive which, when used in the regular cyanide plating bath, will give bright to brilliant deposits of zinc simply and economically without special equipment.

Reynolds Metals Co. reports a product consisting of aluminum foil coated with plastic to build up a base sheet for the production of metal containers similar to tin cans. The material to be packaged determines the type of plastic used in the coating. Thus far, it is expected that polyethylene and vinyl resins will be used. The cost of the product will be competitive with tin. Although aluminum is restricted, it is a domestic product, while tin must be imported.

The Cambridge Instrument Co. is marketing a portable, direct reading pH meter for plant use. The instrument operates from a 110 a.c. line. It has a direct reading scale, graduated from 0 to 14 pH in 0.2 steps. Readings can be interpolated to 0.05 pH with an accuracy of 0.1 pH. Automatic temperature compensation is provided over a range from 2 to 100°C. by a resistance thermometer.

The *Journal of Applied Physics* for Sept., 1950, pages 909–917, reports on generalized microscopy and the two-wavelength microscope. With this new microscope, it has been possible to photograph the structure of the atom for the first time. A photograph shows Marcasite (FeS_2) magnified 2,200,000 times.

Concord Chemical Co. (Moorestown, N. J.) has developed Parwax which is similar to the imported carnauba wax in melting point and viscosity. It gives gloss readings considerably higher than carnauba wax and may be applied in self-polishing formulas. The material is free from resins and contains no plastics or cellulose.

The Acme Shellac Products Co. (Newark, N. J.) is using Cold-Pro, a new cold process for bleaching shellac. It is claimed that this method results in a better control of the wax content, melting point, acid content, and gives a more uniform product. Due to keeping the shellac cold in processing the color, toughness, body, cutting time, solubility, and stability are all improved.

The *Aminco Laboratory News* for March, 1951, page 9, lists para-alpha-dimethyl-styrene as a new raw material for synthetic rubber. This styrene is obtained from the waste liquor from spruce pulp.

Schwartz Chemical Co., Inc., are marketing a rubber plasticizer called Rub-R-Vive which, it is claimed, will prolong the life of all rubber products used by printers. The material is a noninflammable, nonvolatile liquid which, when applied to rubber products, gives them the resilience of new rubber.

Paul R. Cutter (Matawan, N. J.) has been assigned U. S. pat. 2,538,831 (Jan. 23, 1951) for an electrolytical treatment of magnesium or magnesium-base alloys which create a hydrated oxide coating on the metal. By dipping the treated metal in a bath containing a water-soluble metallic salt of acetic acid and then into a dye bath, any color can be applied to the metal. It is possible that this process might be applied to magnesium powder to produce colored metallic pigments.

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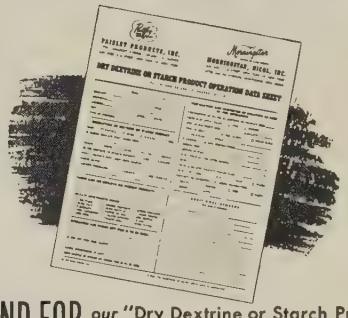

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is producing a barrier cream to protect against oils and inks. The material is called Craftsmen Hand Cream. It is soluble in water, but not in oils.

The General Electric Co., Ltd. (*British Printer*, May-June, 1951, page 48) has a pocket-size film thickness meter. It is designed for measuring nonferrous sheets. The device is a magnetic reluctometer which operates on the moving-iron principle. The characteristics of the magnetic component vary to the proximity of its extremity (a hardened steel spherical projection which rests on the sample) to any ferrous plate. Small variations in distance from the plate produce large variations in the gage. The instrument is sold in three scales: 0–5, 0–10, and 0–30 thousandths.

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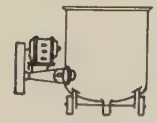
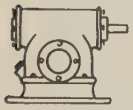
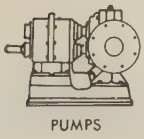

MIXERS AGITATORS


SPEED REDUCERS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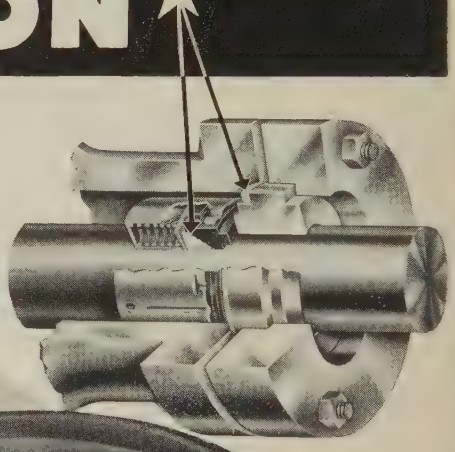

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But where, you might ask, is the connection with Sulphur? Fertilizer, to take just one phase of agriculturally-used chemicals in which Sulphur was used either as a component part or as a processing element! Superphosphate, the base of the most widely used manufactured fertilizer, requires about 200 pounds of Sulphur for every ton produced.

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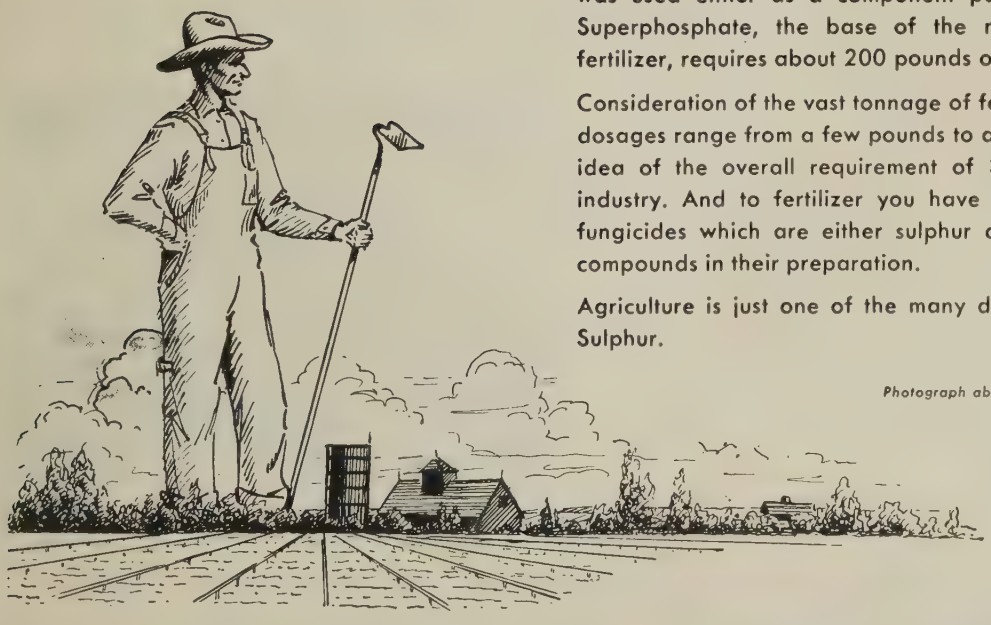
Agriculture is just one of the many destinations of great tonnages of Sulphur.



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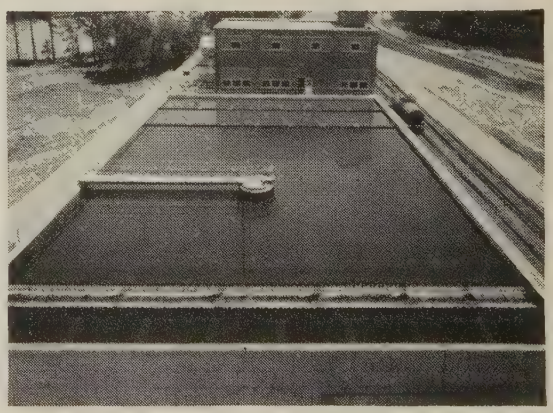

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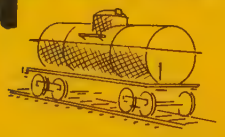
the original chemical size



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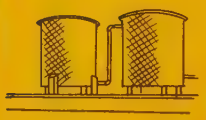

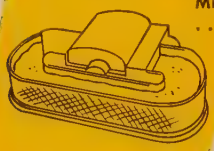

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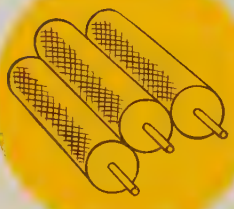

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FREE—ask for your copy of our useful Paper Mill Roll Grinder Catalog, today.

Rugged, extremely accurate, with ease and flexibility of operation . . . these giant LOBDELL Type CW Roll Grinders, are a fitting supplement to the giant paper machines of today. The huge rolls of today's machines are within the medium range, rather than close to the top limit of this big Grinder's capacity. Accuracies of .0005" on the diameter of a press roll with a rubber cover hard enough to measure accurately *are usual* . . . accuracies of .00025" and closer are obtained on straight or crowned rolls of chilled iron. Made in two sizes with capacities of 48" and 60" diameter and with bed length to suit the length of roll face . . . these Grinders are designed for Direct Current operation, but for connection to an A.C. power supply. Other Lobdell Grinders, Type GHV for A.C. operation are made in three smaller sizes to suit the requirements of any mill.

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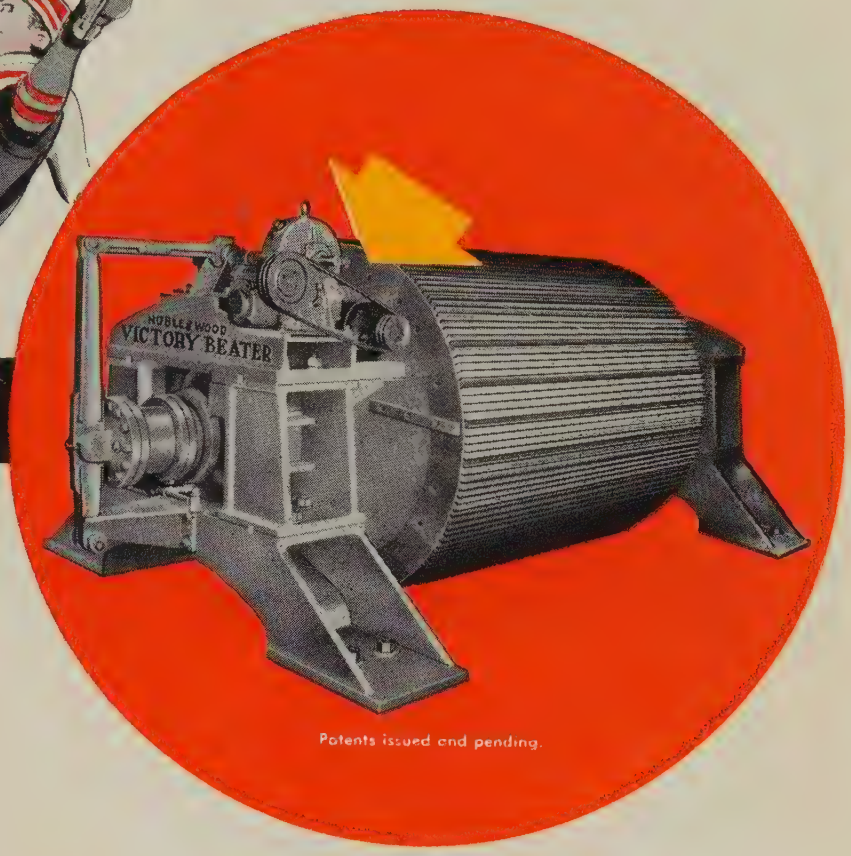

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1. *Controlled Flow — uniform, positive fibrillation*
2. *Pressurized bedplates*
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4. *Centralized bedplates assure 100% roll-bedplate contact*
5. *Highest effective inch cut potential*
6. *Horizontal roll oscillation makes bars self-honing*
7. *Lowest maintenance cost*
8. *Tailored-to-your-plant, low-cost installation*
9. *Spherical anti-friction roller bearings*
10. *1000 gallons per minute capacity*
11. *Highest quality, high tonnage production*
12. *All-time record for continuous production!*

IN THE *Controlled Flow* VICTORY BEATER horizontal oscillation of the roll over the centralized, hydraulically-controlled bed plates provides automatic honing, eliminates ridging and keeps the bars smooth. Bars are always in perfect shape to assure uniform stock treatment. This unique feature also reduces maintenance and operating costs to a minimum.

VICTORY BEATERS are made in two styles: (a) **Single Roll** units for handling batches as small as 500 pounds. (b) **Multi-Roll** units with two, three or more rolls for treating 100, 150, 200 or more tons per day on a continuous production basis. The superiority of the *Controlled Flow* VICTORY BEATER is a matter of on-the-job performance records by some of the world's largest paper producers. ***All the facts are available for your examination. Write, wire or phone today for Booklet T452***

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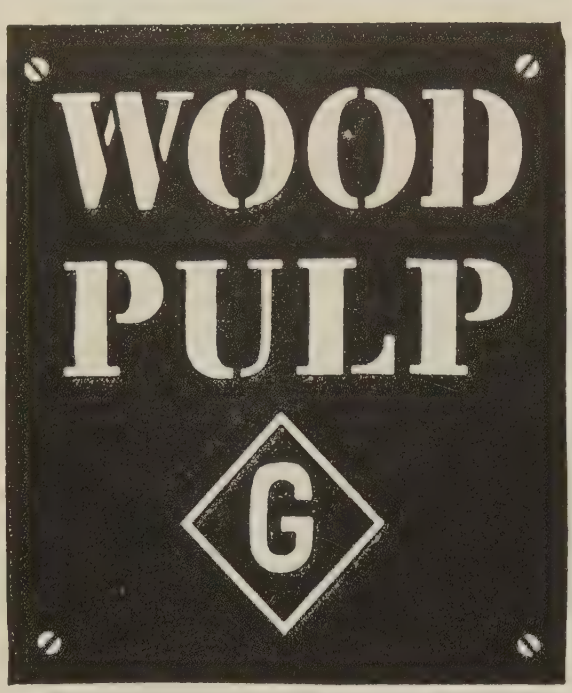
Established 1886



"Our principles can never be defeated."
WILLIAM LLOYD GARRISON

America's growth and progress result from a combination of exceptional natural and human resources, in a system of free enterprise—all based on the principles of our founding fathers.

The same factors will continue to add strength to our nation and its industrial fabric, with Pulp and Paper ever broadening its field of usefulness and increasing its importance.

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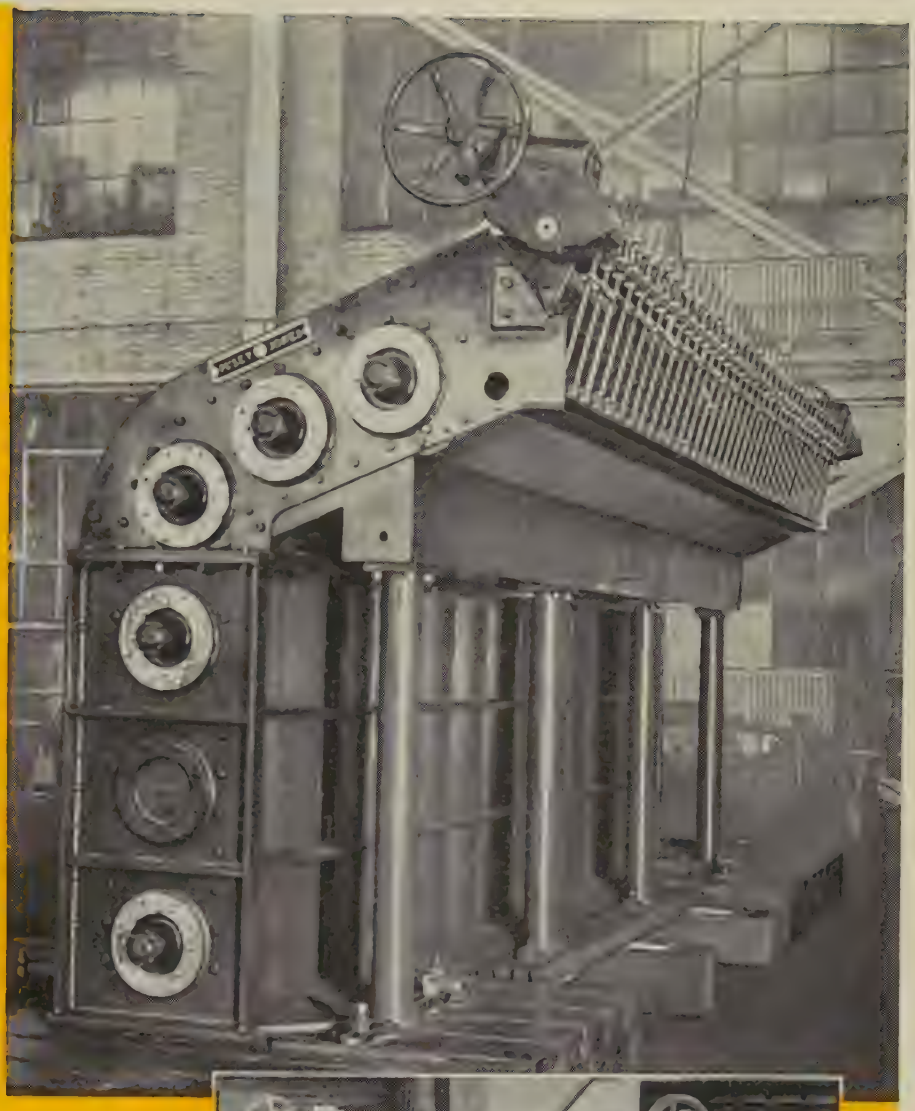
Improved High-Speed Slice



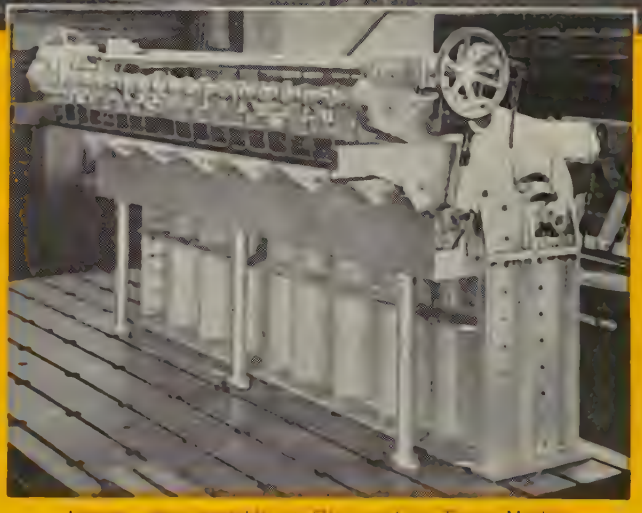
The Puseyjones Closed Pressure Slice, after several years of development and improvement, is now considered a "must" on today's high-speed machines.

Used in connection with the Puseyjones Flow Spreader, it provides an ideal approach flow to the fourdrinier, but may also be used with any form of multiple inlet type distributor when required by space restrictions or mill preference.

Now in operation on high-speed machines running on tissue, multi-wall bag, and under construction for liner board, it is the most compact and least complicated type of stock inlet available.

When rebuilding for higher speed and production, the saving in space usually permits lengthening the wire from 10 to 15 ft.

For complete details on the Puseyjones Closed Pressure Slice for your new or rebuilt machine, write or call us today.



[illegible] of Slice used on Tissue Machine having 154" wire.

Top: shop assembly of Slice used on Multi-Wall Bag and Liner Board Machines. As shown, suitable for 228" wire.

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Established 1848. Builders of Paper-Making Machinery

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THE SIGN OF TRADE MARK SUPERIOR QUALITY

"Here's the adhesive for coating pigments that binds them to the stock BETTER and EASIER!"

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ALPHA PROTEIN

This is the pure Soya Protein that does so many jobs better in the paper industry.

GLIDDEN ALPHA* PROTEIN *was the first pure protein chemically isolated from the soybean ever to be produced on a commercial scale for industrial use. Today, in the paper industry alone, it is performing a variety of important jobs* better—*often more economically, too.*

AS AN ADHESIVE FOR PIGMENTS used in coating printing papers, Alpha* Protein is stable in solution over a wide range. It is compatible with the various types of pigments and binds them to the fibre of the raw stock easily.

It does not affect, to any extent, the brightness or hiding power of pigments used. Alkaline-cut Alpha* Protein adhesive permits addition of formaldehyde to coating colors to make the finished paper water-resistant. And many other advantages have made Alpha* Protein a truly superior adhesive for paper coating!

IN BEATER SIZING, ALPHA* PROTEIN IS A primary ingredient in the patented Glidden Prosize Process which users have reported gives six big advantages, including greater sizing efficiency at lower cost. In tub and calender sizing and in laminating, Alpha* Protein has demonstrated properties which have made it the choice of numerous mills.

IN THE COATING AND PRINTING OF WALLPAPER —especially the washable type, in the coating of insulation board and in many other uses, Alpha* Protein has proved itself a valuable material.

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WRITE FOR ADDITIONAL INFORMATION *on this versatile soya protein material—and its possible application to your product or process. A representative of the Glidden Technical Service will call if you wish.*

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Dynamic Separation saves Money

INFILCO
BETTER WATER CONDITIONING AND WASTE TREATMENT SINCE 1894

OFFERED ONLY BY THE

Accelator®

IN ECONOMICAL WATER TREATMENT, an Accelator occupies but a fraction of the space of an "old-style" treatment plant because it is a single unit . . . because it eliminates the previous multiple steps of mixing, sedimentation and coagulation. The unique dynamic separation principle of operation

(continue to next page)

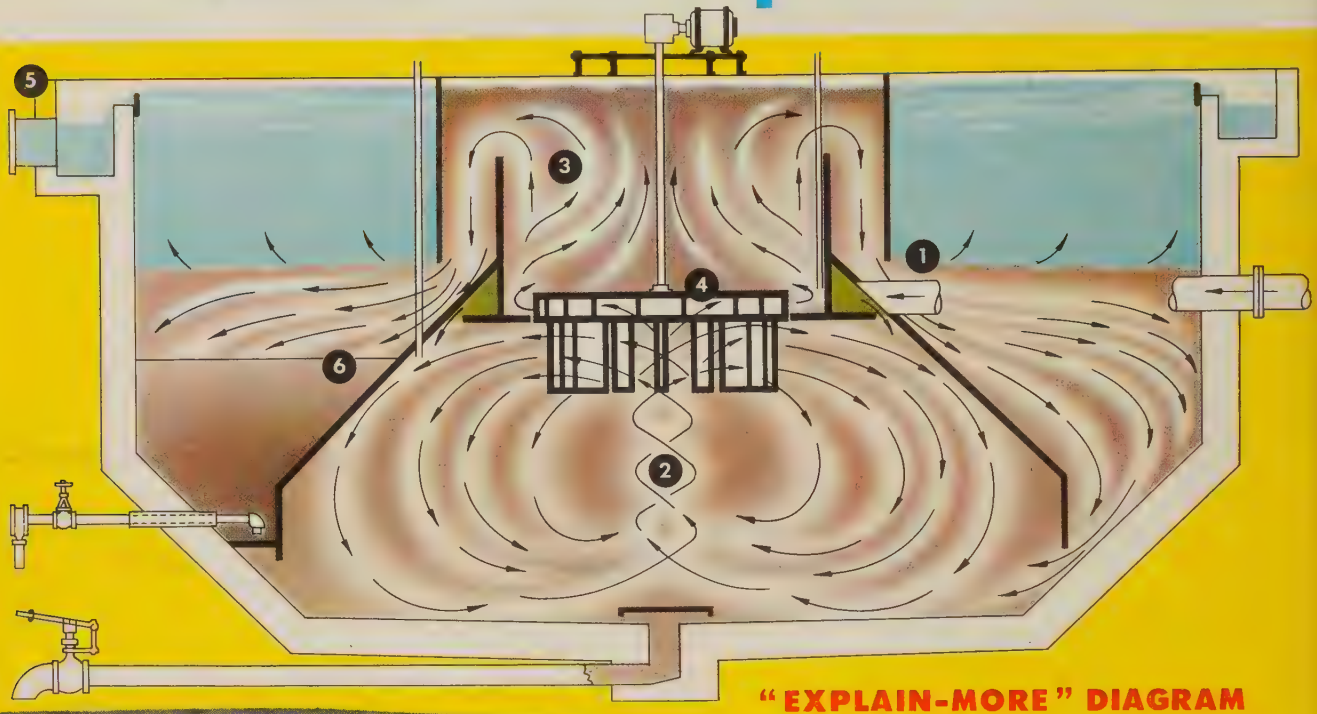
(from preceding page)

permits the treated water to separate from the top of a downward-moving pool of uniformly sized slurry in contrast to having the treated water filter upward through a suspension of sludge of gradually decreasing particle sizes.

INFILCO INC. ★ *Tucson, Arizona*

Outstanding advantages—based on more than two thousand Accelator efficiency-of-operation reports:

- ★ Faster separation of solids from treated water
- ★ Low-velocity movement of tremendous quantities prevents floc break-up
- ★ Rapid mixing of incoming water and chemically impregnated slurry
- ★ Small or large flows have complete contact with slurry
- ★ Thickened sludge is automatically drawn off
- ★ Settling-out of solids is prevented



"EXPLAIN-MORE" DIAGRAM

the Accelator basin contains:

1. A raw water inlet and distributing duct
2. A primary mixing and reaction zone
3. Two concentric draft tubes which form the secondary mixing and reaction zone
4. A rotor-impeller for mixin and pumping, driven by motorized reducer
5. An effluent launder system
6. Concentrators to accumula and remove excess slurry

PLAN OF ACCELATOR

TWIN ACCELATOR FILTER PLAN
If for softening, a recarbonating basin is placed between Accelator and filters

TYPICAL ACCELATOR LAYOUT

SUGGESTED ACCELATOR APPLICATIONS / POSSIBLE TREATMENT REQUIREMENTS → / WATER END-USE	SOFTENING	CLARIFICATION	STABILIZATION	ALKALINITY REDUCTION	ORGANIC MATTER REMOVAL	TASTE AND ODOR REMOVAL	COLOR REMOVAL	IRON REMOVAL	SILICA REDUCTION	NEUTRALIZATION
MUNICIPAL	X	X		X	X	X	X	X		
PULP	X	X		X	X		X	X		
PAPER	X	X		X	X		X	X		
BEVERAGES		X		X	X	X	X	X		
COOLANT	X	X	X	X	X			X		
BOILER FEED	X	X		X	X		X	X	X	
RAILROADS	X	X					X			
TEXTILE	X	X			X		X	X		
CANNERIES		X		X	X	X		X		
BREWERIES		X		X	X	X	X	X		
OIL FIELD FLOODING		X	X		X		X	X		
BRINE DISPOSAL		X	X		X		X	X		
INDUSTRIAL WASTES		X	X		X		X			

TROPICAL WOODS AS A SOURCE OF PULP

Symposium at The Institute of Paper Chemistry, Appleton, Wis., Sept. 17, 1951, in connection with the open meeting of the FAO Technical Committee on Wood Chemistry

Introduction

HARRY F. LEWIS

It is a real pleasure for me to welcome such a large group of wood chemists and pulp and paper technologists to this opening session of the International Pulp and Paper Symposium. The papers of today and tomorrow (Sept. 17 and 18, 1951) will be given under the sponsorship of the FAO Technical Committee on Wood Chemistry.

One of the important issues facing those interested in expansion in the manufacture and use of pulp and paper on a world-wide scale is the source of the fibrous raw material from which to make first the pulp and then the paper. Certainly the wood resources of the United States, Canada, and the western half of Europe cannot support in any permanent way a greatly increased industry, and the enormous wood resources of the U.S.S.R. are not available. It becomes necessary, therefore, to locate currently unused fibrous materials. These meetings of today and tomorrow define the possibilities inherent in the two greatest available fibrous reservoirs—namely, the tropical woods and the agricultural residues.

In the symposium on tropical woods, one session is concerned with the availability, nature, physical, chemical, and fiber characteristics of the woods making up at least a part of the tropical forests. These are principally hardwoods. A second session will relate to the problems involved in the pulping of these woods as experienced by investigators in Africa, South America, and Central America. It will quickly become apparent that the problems of the forester and pulp manufacturer have not all been solved.

Harry F. Lewis, Dean, The Institute of Paper Chemistry, Appleton, Wis.

Species Sampling on a Reproducible Basis

C. M. STEWART, D. H. FOSTER, W. E. COHEN, R. T. LESLIE, and A. J. WATSON

More frequently than not, wood samples which are used for chemical investigations and pulping studies are not representative of the species or even of an individual tree. Therefore, a true assessment of a specified property of a given species is not possible and, at most, the data are suitable only for screening tests. In many laboratories, wood chemical investigations are long-term projects extending over many years and, in some cases, over decades. To have any real and permanent value, it is most essential that such investigations should yield data which would be amenable to correlation from year to year or even from one decade to the next. This ideal could be met if one and the same wood sample were to be used continuously for all investigations but for various obvious practical reasons—e.g., storage capacity and deterioration and possible contamination during storage—this is not feasible. The practical alternative is to use samples which, at any chosen time, may be reproduced within set limits of accuracy for either specified or general properties. For certain fundamental projects these reproducible samples would not necessarily have to be representative of the species, although it is very desirable that they should be.

For fundamental investigations, it is advantageous to minimize the effects of chemical and physical variations in wood laid down under different conditions—e.g., climate, environment, and height in tree—by taking the wood from a fixed height above ground level and from within specified growth rings of heartwood.

Because of its importance, it was decided to prepare a reproducible sample of *Eucalyptus regnans* F.v.M. Data from past work on this species were inadequate for calculating the number of trees from which wood should be taken and it was necessary, therefore, to obtain this information as the project developed. With this in mind, butt samples of the 12 outermost growth rings of heartwood were collected from at least 20 trees selected at random from various widely scattered forestry districts in the State of Victoria. The trees varied in age from 24 to 200 years. The samples were taken at a distance of approximately 10 meters above ground level (*E. regnans* trees may attain a height of 90 meters).

Each sample consisted of two diagonally opposite billets from approximately 1-meter lengths of tree trunk. The 12 outermost growth rings of heartwood were sepa-

C. M. Stewart, D. H. Foster, and A. J. Watson, Research Officers, Wood Chemistry Section; W. E. Cohen, Senior Principal Research Officer, Wood Chemistry Section, Division of Forest Products; and R. T. Leslie, Section of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization, South Melbourne, Australia.

rated from the rest of the wood and converted to shavings, 10 to 120 mu thick, by longitudinal cuts on the tangential face of the billets. The shavings were exhaustively extracted with cold filtered town water (72 hours with replacement of water every 3 hours), ethanol at 55°C. (24 hours with replacement of ethanol every 8 hours), and with distilled water at 55°C. (24 hours with replacement of water every 8 hours). At the end of each main extraction—i.e., water, ethanol, water—excess solvent was removed from the shavings by centrifugal action. Mechanical action during the final water extraction converted the shavings to fiber bundles which generally are suitable for analysis and for other chemical treatment. This material, after centrifugal drying, was supported in frames clothed with bronze wire mesh and kiln dried at 38°C. to a moisture content of not less than 10%.

After analysis had shown that the extraction treatment of each sample had been effective the first reproducible bulk sample (approximately 45 kg.) was prepared by mechanically agitating a cold water suspension containing equal weights of each butt sample. The mixture was then dried as described above and stored in a dustproof container.

ANALYTICAL DATA

Choice of Converting Equipment. Before the samples were collected it was necessary to select a method of converting the wood to a form suitable for extraction and analysis. The Wiley mill was considered to be unsuitable because (1) its materials of construction were not resistant to the acids and tannins in "green" hardwood; (2) its capacity was too small for the large sample contemplated—viz., 40 to 50 kg.; and (3) insofar as possible, it was desirable that cutting of fibers should be minimized. After some preliminary trials a thicknesser which could be fed at constant speed was chosen. This could be suitably adjusted to produce longitudinal shavings, 10 to 120 mu thick, from the tangential face of a billet or flitch.

The suitability of thicknesser shavings for analysis was demonstrated by comparison of analytical data on shavings prepared from selected wood samples of *E. regnans* and *E. marginata* Sm. with those on 60-mesh wood meal prepared from the same wood samples in the Wiley mill. *E. marginata* was purposely chosen because of its high content of cellular "kino." The results, which are shown in Table I, demonstrate that thicknesser shavings can be handled conveniently by the analytical methods. In the case of *E. regnans* the shavings appear

Table I. Analysis of Wood Meal and Thicknesser Shavings Prepared from Selected Samples of *E. regnans* F.v.M. and *E. marginata* Sm.

	Eucalyptus regnans		Eucalyptus marginata	
Property	*Wood meal (Wiley 60-mesh)*	*Thicknesser shavings*	*Wood meal (Wiley 60-mesh)*	*Thicknesser shavings*
Hot water solubles, %	3.4	3.0	4.4	4.8
Alkali solubles (0.1 *N*), %	15.6	15.4	30.6	29.3
Lignin (Klason),[a] %	23.0	23.8	41.8	40.4
Chlorine holocellulose, %	77.4	79.6	62.0	62.3
Alpha-cellulose, %	39.5	40.3	37.2	37.4

[a] On unextracted wood and, therefore, includes cellular kino, especially in the case of *E. marginata*.

Table II. Results of Successive Extraction Treatments of As-Received Thicknesser Shavings of *E. regnans*

(All Results Expressed on Extracted-Wood Basis)

Sample	*Soluble in cold water, %*	*Additional material soluble in ethanol at 55°C., %*	*Additional material soluble in water at 55°C., %*	*Total solubles, %*
36-2/1B	9.5	1.9	4.7	16.1
36-2/2B	11.7	0.9	4.5	17.1
36-3B	0.5	3.5	2.6	6.6
36-4B	0.0	4.9	1.7	6.6
36-5B	0.0	2.5	1.1	3.6
25-1B	2.4	3.6	1.2	7.2
38-3B	0.4	4.1	0.3	4.8
38-5B	0.6	2.0	1.5	4.1
39-1B	6.0	3.8	4.2	14.0
39-1C	1.2	3.3	1.5	6.0
39-1T	2.8	3.9	4.9	11.6
39-2B	1.5	4.2	2.2	8.0
39-2C	2.6	4.2	3.4	10.2
39-2T	4.5	8.0	5.6	18.1
39-3B	0.0	0.4	2.9	3.3
39-3C	0.0	1.8	0.8	2.6
39-3T	1.1	1.1	0.0	2.1
39-4B	0.0	1.4	0.6	2.0
39-4C	0.0	1.5	1.1	2.6
39-4T	0.0	0.4	0.5	0.9
39-5C	0.0	2.0	2.2	4.2
39-5T	0.0	3.8	1.2	5.0
41-1B	2.4	1.4	1.4	5.2
41-2B	1.5	3.1	2.2	6.8
41-3B	0.0	4.7	3.2	7.9
42-1B	0.0	4.1	2.7	6.8
42-2B	0.7	1.5	2.3	4.5
Maximum	11.7	8.0	5.6	18.1
Minimum	0.0	0.4	0.0	0.9
Mean	1.49	2.95	2.15	6.59
Standard deviation	2.41	1.70	1.47	4.38
Coefficient of variation, %	162	58	68	66

Notes: (1) Solubles in samples 36-1B, 38-1B, 38-2B, and 39-5B were not determined on as-received material. (2) In the sample numbers, B = butt, C = center, T = top.

to have some advantage over wood meal because the higher values for chlorine holocellulose and alpha-cellulose are consistent with less degradation during their isolation. In the case of *E. marginata*, the lower alkali solubles and lignin contents of the shavings suggest that some kino was dislodged from ray parenchyma cells and vessel elements and was not included in the samples taken for analysis.

Extractives. Quantitative extractions on small samples were made under conditions identical with those on the large scale. Table II contains the results for the butt samples from all trees, as well as those for the center and top samples from five trees within one forestry district. They demonstrate the wide variation, in quantity and nature, which must be expected within and between trees of a species. They may not account for cellular kino which is more often than not insoluble in water and alcohol, but which is soluble in hot dilute sodium hydroxide.

Wood substance. Chlorine holocellulose, lignin (Klason), pentosans, and methoxyl groups were determined on the various bulk-extracted samples. The results (Table III) show that pentosans were lost by some samples during the extraction treatment and during the isolation of chlorine holocellulose; predisposition toward pentosans loss during the latter treatment probably resulted from mild hydrolysis during the hot water extraction. It is to be noted that, where samples have a high lignin content, the methoxyl content of the lignin is low. This is partly attributable to the inclusion of extraneous substances (e.g., kino) which are

insoluble in water and in alcohol, especially in the case of samples initially high in solubles. Microscopic examination revealed that, with increase in total solubles, there was an increase of kino in the ray parenchyma cells. The following correlations, some of which are probably influenced by this or by the empirical nature of the analytical methods, have been established: (1) lignin and methoxyl in lignin (1% level), (2) lignin and methoxyl in holocellulose (1% level), (3) lignin and total solubles (1% level), (4) lignin and age of tree (5% level), and (5) pentosans and height of sample in tree (5% level).

The last-mentioned correlation applies, of course, to the butt, center, and top samples of five trees within one forestry district.

Sulphate Cooks. All the extracted samples were subjected to identical sulphate cooks, the conditions having been chosen as the result of some preliminary cooks. Because of the greater bulk of the disintegrated shavings, as compared with that of the chips, it was necessary to employ a liquor ratio of 12:1 and 20% total alkali. The sulphidity ratio was 25% (Na_2S expressed as Na_2O on the basis of total alkali, also expressed as Na_2O). The time schedule was 40 minutes from 100 to 160°C. and 2 hours at 160 ± 2°C. Pulp yields are also shown in Table III. It is to be noted that the pulp yield varied approximately inversely with the sum of lignin plus pentosans in the wood [i.e., 100 − (lignin % + pentosans %)].

Thirteen of the extracted samples were cooked on a larger scale to provide sufficient pulp for evaluation. Because the pulps contained considerable proportions

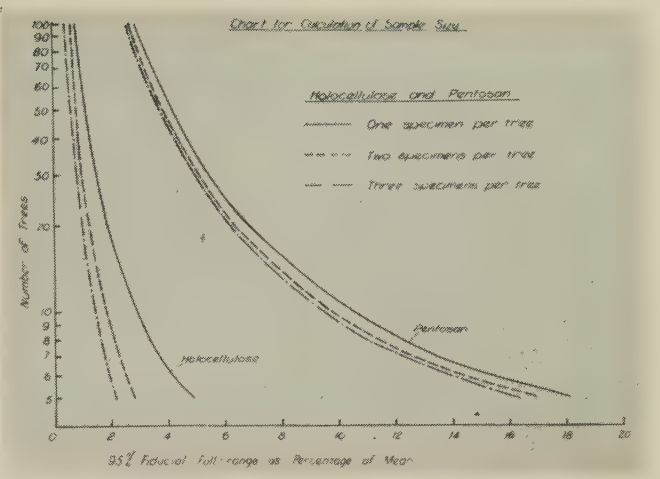


Fig. 1

of cut or broken fibers their strength properties were only about 70% of those of normal eucalypt sulphate pulps. Even after allowing for this the variation in unbeaten and beaten strength properties was considerable and sufficient to indicate that pulps produced under identical cooking conditions had widely differing strength properties and thus emphasized the necessity for sampling procedures. Thus, for unbeaten pulps, the burst factor varied from 4 to 22 and the tear factor from 17 to 44; for pulps beaten for 18,000 revolutions, in the Lampén mill, the burst factor varied from 36 to 62, the tear factor from 47 to 58, and the folding endurance (M.I.T.) from 25 to 1800.

Table III. Composition of the Various Extracted Samples

(Except where otherwise stated, results are expressed on the basis of extracted wood)

Sample	Chlorine holocellulose, %	Lignin (Klason), %	Sulphate pulp yield, %	Pentosans in Unextracted wood, %[a]	Pentosans in Extracted wood, %	Pentosans in Holocellulose, %	Methoxyl in Holocellulose, %	Methoxyl in Lignin, %[b]
36-1B	79.6	23.0	58	..	17.2	15.4	1.0	21.8
36-2/1B	77.0	27.1	54	..	17.6	15.6	1.2	20.6
36-2/2B	78.9	26.5	55	17.9	17.6	16.5	1.4	21.6
36-3B	78.5	25.2	57	..	16.6	16.1	1.1	21.6
36-4B	80.4	20.1	62	..	16.2	16.4	1.0	22.7
36-5B	79.4	20.2	60	..	16.0	15.3	1.4	23.0
25-1B	79.3	22.9	58	15.9	15.8	15.7	1.2	22.9
38-1B	80.5	23.3	60	..	16.6	16.7	1.0	21.9
38-2B	79.2	20.6	60	..	16.1	15.4	1.1	22.9
38-3B	80.1	22.4	58	..	16.4	15.2	1.2	22.0
38-5B	80.5	20.5	59	..	16.3	16.2	1.0	22.7
39-1B	78.8	25.9	55	18.3	16.3	15.8	1.6	21.5
39-1C	80.7	23.8	59	16.3	16.0	16.2	1.3	21.8
39-1T	76.0	23.1	56	17.2	15.9	15.1	1.0	21.9
39-2B	79.2	24.1	56	..	15.4	15.1	1.3	22.6
39-2C	78.6	25.5	55	..	15.8	15.5	1.3	21.7
39-2T	74.8	26.9	53	..	16.8	16.3	1.3	20.2
39-3B	78.8	23.4	58	..	16.9	16.3	1.1	21.3
39-3C	79.7	21.9	58	..	16.9	15.8	1.0	22.5
39-3T	81.1	20.3	58	..	17.9	18.0	1.2	22.9
39-4B	81.8	20.4	60	15.5	15.9	14.6	1.2	22.2
39-4C	80.9	21.6	59	15.9	15.8	15.7	1.1	22.4
39-4T	81.5	22.5	58	17.6	17.4	17.5	1.2	22.2
39-5B	80.1	25.4	57	..	18.6	17.3	1.3	21.6
39-5C	81.8	23.2	55	..	19.0	17.3	1.3	22.4
39-5T	81.3	22.5	56	..	19.6	17.9	1.4	22.2
41-1B	80.9	23.1	59	14.0	13.5	12.7	1.3	22.9
41-2B	79.5	24.4	57	..	16.2	16.1	1.4	21.8
41-3B	78.6	24.2	56	..	17.3	16.8	1.2	22.2
42-1B	81.1	25.5	57	..	16.1	15.8	1.7	22.1
42-2B	78.6	23.2	56	..	15.8	15.9	1.0	21.8
Maximum	81.8	27.1	62	..	19.6	18.0	1.7	23.0
Minimum	74.8	20.1	53	..	13.5	12.7	1.0	20.2
Mean	79.6	23.2	57.5	..	16.6	16.0	1.26	22.1
Standard deviation	1.58	1.96	2.03	..	1.17	1.04	0.18	0.63
Coefficient of variation, %	2.0	8.5	3.5	8.3	7.0	6.5	14.2	2.8

[a] Expressed on the basis of extracted wood; not determined on all samples.
[b] Expressed on the basis of lignin.

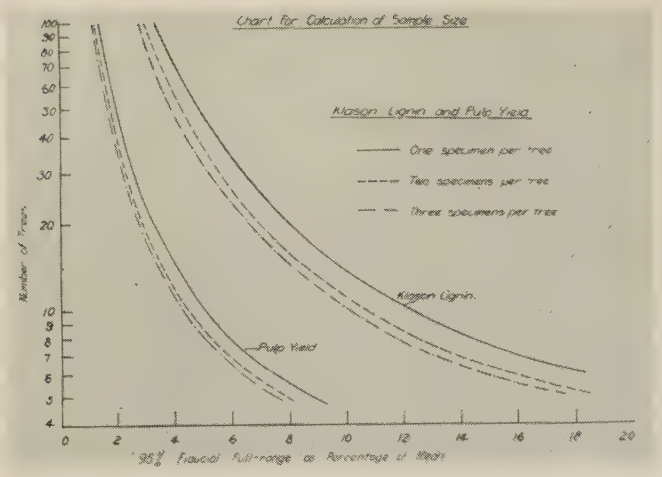


Chart for Calculation of Sample Size
Klason Lignin and Pulp Yield
One specimen per tree
Two specimens per tree
Three specimens per tree
Klason Lignin
Pulp Yield
Number of Trees
95% Fiducial Full-range as Percentage of Mean

Fig. 2

Statistical Treatment of Data. Statistical examination of the analytical data showed that the samples were adequate for estimating the required size of future sampling programs for reproducible samples of *E. regnans*. For the chemical properties determined no evidence of differences between areas was observed. In general, the variation between trees was greater than that within trees and the between-tree variation was found to agree very well with that of past work on this species (*1*).

The data have been used to construct curves (Figs. 1 and 2) from which may be determined the number of trees of *E. regnans* which are required to produce a sample the properties of which fall within chosen limits. For example, suppose that it is desired to sample *E. regnans* for an assessment of lignin content and to be reasonably certain that the estimate of the species mean is within a 5% range (i.e., ±2.5%) of its true value. Reference to Fig. 2 shows that these requirements should be satisfied by collecting 80 samples from 40 trees (2 samples per tree) or 50 samples from 50 trees (1 sample per tree). Figures 1 and 2 also show that there is little advantage to be gained by taking more than one sample per tree. It should be remembered, however, that these curves refer only to the outer heartwood of the species and that other curves would have to be prepared for all heartwood or for other heartwood zones.

The composite sample obtained by mixing the various samples of shavings, as just described, is reproducible from time to time. However, it is not truly representative of the species because it is from outer heartwood from a fixed height, and is not volumetrically representative. For many purposes a sample which is truly representative of a particular forest area may be required. For example, it may be necessary to determine the number of trees, of one or more chosen species, which will produce a composite sample whose pulp yield will be within 5% of the estimated species mean. The following procedure would then be followed:

1. *Select one sample from each of, say, ten trees.* For the forest under consideration, the selection must be random with respect to the location of the tree and to the position of the sample in the tree. In order to take care of horizontal within-tree variations, the samples should consist of whole cross sections of the tree. The vertical within-tree variations are likewise, but not to the same extent, eliminated by taking each cross section from a random position up the merchantable bole of each tree. In order to make some allowance for the volume of timber the cross sections should be cut so that their length is proportional to the height of the bole. The height of each merchantable bole and the area of each cross section should be recorded. The whole of each cross section should then be converted to chips. If this is likely to produce too many chips for convenient handling, they should be prepared from randomly selected, equiangled, diagonally opposite sectors from each cross section. If a composite sample representative of the forest area is required then, at this stage, the chips produced from each cross section should be mixed together in weights which are proportional (by weight) to their parent cross sections (or pairs of sectors).

2. *Determine the pulp yield on each of the ten selected samples.* The coefficient of variation is first determined.

$\bar{x}$ = species mean on the volumetric basis
h_i = height of merchantable bole of the ith tree
A_i = area of cross section of sampled portion of the ith tree
x_i = the observation or property of the ith tree
C = coefficient of variation
s = the standard deviation of the individual result
n = number of trees (one sample per tree)

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i h_i A_i}{\sum_{i=1}^{n} h_i A_i}$$

and

$$s = \sqrt{\frac{\sum_{i=1}^{n} h_i A_i x_i^2 - \bar{x}_i \sum_{i=1}^{n} h_i A_i x_i}{\sum_{i=1}^{n} h_i A_i}}$$

Then the coefficient of variation, C, $= 100s/\bar{x}$.

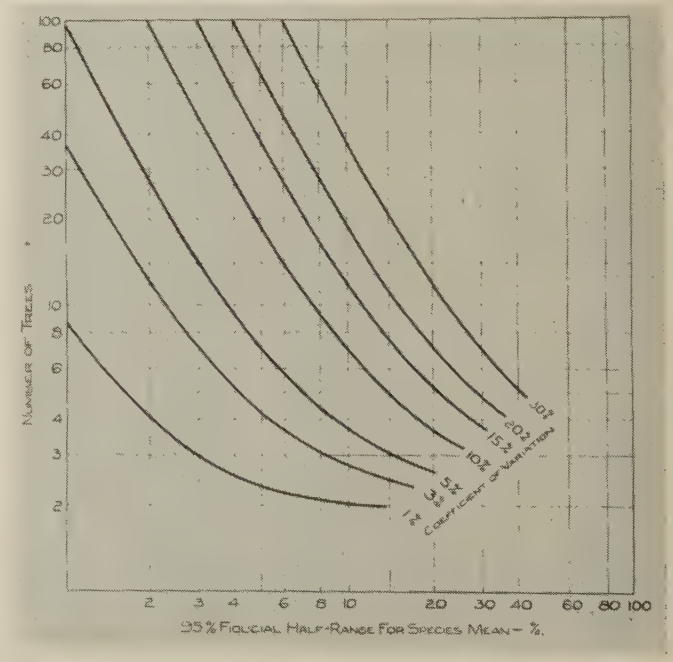


Fig. 3

3. *A first approximation to the total number of trees required for set accuracy may now be obtained from the theoretical curves shown in Fig. 3.* This figure may be used for any physical or chemical property or for any species. Therefore, for calculating a more accurate estimated species mean, the basic density of each cross-section sectional disk should be determined and the property under consideration should be expressed on the weight per volume basis—i.e., grams per cubic centimeter or kilograms per cubic meter.

One sample per tree has been suggested because, for most known properties, the between-tree variations are greater than those within trees. However should it be known that, for a particular property, the variation with height is significant, then stratified sampling would be indicated.

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Pulpwood from Tropical Forests

ROBERT W. HESS

Any discussion on tropical forests soon brings out the tremendous scope and the interminable ramifications of the subject. If the extent of these forests, their composition, wood volumes, forestry requirements, and utilization are considered, the subject becomes vast. The experience of temperate forestry is inadequate to span the extremes found in all these regions and it is difficult to make a logical generalization from the enormous number of variants. That the forests can be studied and classified into workable forest types is plainly evident by the excellent work done in some regions. The extent of this detailed classification and enumeration, however, is pitifully small in comparison with the needs. The development of forestry practices and adequate utilization studies lag far behind. Fortunately, taxonomic botanists have explored most regions of the earth and have identified most of the important species.

Prospects of obtaining any large amount of additional information in the near future are not promising. It is true that worth-while projects of significant scope are being carried on in various parts of the world; the fact remains, however, that, for almost any given tract of timber in the less heavily populated regions of the tropics, very little information can be found concerning the physical, chemical, or processing properties of the woods, the silvical characteristics of the trees, or the silvicultural methods applicable to the type of forest. More forums and publications are needed to bring out available information and greatly increased facilities for studies of tropical timbers and forests are required to supply basic data.

The dearth of specific information should not deter the utilization of tropical forests. Scattered information points the trends, fundamental principles are applicable, and carefully directed *applied* research can yield answers in a comparatively short time.

AVAILABLE TIMBER SUPPLIES

Although the area of tropical forest land of all types is very large, that which is capable of continued production of wood for pulp is less than half of most published figures. Many forest regions of the tropics support a much higher population than is generally realized. A large proportion of these people practice some form of shifting cultivation which removes the timber and in some areas depletes the soil, thus preventing the re-establishment of good forests for very long periods. A large percentage of the tropical soils are clay, whereas some are coarse sand; in both cases, on top of the mineral soil, there is a layer which is very high in organic matter. After exposure to sun and heavy rains for one to two years, as with farming, the organic matter is virtually lost. It is not surprising that recently abandoned agricultural lands frequently support only a poor growth of wood tree species. The amount of such cutover land and the condition of the re-stocked farms is a matter for conjecture, but the area is huge and the quality of the new forest is generally very poor. Thus, the search for forests suitable for the production of pulpwood must take into consideration the timber, the soil, and the land history.

Coniferous Forests

The coniferous forests of the tropics are relatively small in extent and most of them are being heavily cut. The pines of Mexico and Central America offer possibilities for pulp and lumber production in certain areas, particularly if a planting program is started at an early date to supplement the acreage of old growth now in existence. In most regions considerable railroad or main automobile road construction will be required before pulpwood can be hauled to a suitable mill site. Large rivers are commonly available at lower levels but the suitability of their water for pulp production is usually unknown.

No coniferous forests are available in northern South America. The heavy cutting of Parana pine in southern Brazil for lumber and veneer makes use of this species in its natural state for pulp problematical. Mexican pines can probably be grown rapidly in this area, offering a means of establishing a permanent source of supply.

Conifers have been largely cut out in Chile except in remote mountain areas and plantations would appear

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to be the only suitable source of large quantities of coniferous pulpwood in most of this region.

The pine forests of the West Indies are of limited extent and heavily cut over. The same is true of coniferous forests of the Mediterranean region. In South Africa extensive areas of exotic pines have been planted and have attained sawlog size. The podocarps and red cedar of northeast Africa are of little interest for new pulp exploitation. Conifers exist in the mountains of southeast Asia and on some of the islands of the southwest Pacific; it is possible that certain areas could be found in these regions which would be suitable for pulp production.

The development of forestry practices for securing a sustained yield in tropical pine forests would not be exceptionally difficult for an experienced forester. Local observations and adaptations of practices in the southern pine areas of the United States would permit a start on a limited basis. Reproduction can probably be obtained satisfactorily wherever there is a fully stocked stand of pine and where intrusive hardwoods are not too plentiful. In areas where hardwoods and pine are mixed, particularly at the highest elevations and in the moister areas at lower elevations, it may prove difficult to prevent replacement of conifers by vigorous hardwoods. As in temperate zone forests, it is important to determine the rate of growth and productive capacity of any tropical coniferous forest selected for possible pulpwood production. Not all tropical forests grow rapidly and many have a low volume yield per acre.

One of the most promising future sources of pulpwood from the tropical regions is from pine plantations. The Australians, New Zealanders, and South Africans have demonstrated the practicability of obtaining very rapid growth and high volume yields from planted exotic pines, and it is reasonable to assume that similar success can be obtained in Central and South America. Careful analysis of the problem and considerable research should precede any large development, but there is every reason to believe that it can be accomplished in a comparatively short period of time. Examination of planted individual trees and any small plantations in the region will yield much information if soil conditions, elevations, rainfall, and other factors are taken into consideration. Studies of natural reproduction in the locality may yield vital data. Provisions for detection and control of disease and insect epidemics should be an integral part of such a program. Although sufficient information exists to permit a reasonably sound selection of species, good management requires a continuing study of better species and strains for increased yields. Location of suitable soil types may prove difficult, especially in areas where farming is extensive. It is assumed that no attempt would be made to establish pines in climatic conditions not known to be suitable for their growth and development.

A reasonable solution to the time factor involved in the production of pulpwood with plantations of tropical conifers would be to obtain a tract of timber sufficiently large to supply the required volume of pulpwood and to pay for planting costs until the plantations begin to produce. Complications will obviously arise in the future as the reproduction of cutover land and the planted stock of the same age classes reach maturity. It should be possible to overcome this maladjustment of the first cutting cycle by varying the growth of natural as compared with planted stock, the age and size at the time of cutting, the use of thinnings while growing a stand of sawlog timber on part of the area, the purchase of pulpwood during part of the period, and similar methods. Careful adherence to well-made long-range plans would be required.

In optimum areas rapid rates of growth may be expected and volume yields of pulpwood may be expected in 12 years, although this may not be the age at which the greatest volume yield per acre is obtained.

Hardwood Forests

The great bulk of the forests in tropical regions consists of hardwoods in varying degrees of mixture. Along the coast a riparian type, often predominantly mangrove, is commonly found, usually forming a narrow band adjacent to, and partly in, the salt water. Immediately behind this in deep swamps and along the large rivers often lie more or less similar swamp types, characteristically one or more species with stilt roots and others with abnormal (sometimes grotesque) developments of root flanges.

These vast areas of mangrove, black mangrove, and swamp forests are a challenge. In addition to the large volume of wood and the comparatively few species involved is the interesting high tannin content of the bark of some species. Reproduction from seed and sprouts will probably be excellent, at least for the second generation. If the wood can be processed to advantage, there remains a development of an efficient, presumably water-borne, means of harvesting the trees from their interlocked stiltlike or high flanged stumps. The adaptation of a barge as a combined skidder and loader, using a cable haul from a spar tree, should permit low logging and hauling costs. Stumpage costs or fees should be extremely low for this at present almost worthless timber.

Above and inland from the swamp forests lie the great tropical evergreen hardwood forests.* These range from periodically inundated lands along the rivers to pockets high on the mountain slopes, and even to forests in the nearly perpetual cloud cover of mountain tops. The forests are evergreen, although some of the trees may lose their leaves periodically. This is the forest that covers enormous areas of eastern Central America, northern South America, the Amazon Valley, West Africa, the Congo River basin, Malaya, Borneo, and the Philippines. It is primarily the extreme heterogeneity of this type of forest that has so far prevented extensive exploitation of its many valuable timbers.

Contrary to the usual concept, within reasonably restricted regions, the number of forest types in the tropical evergreen forest is not excessive. In fact, over hundreds of square miles it may be possible to classify the forests into a dozen major types; a given area of the eastern United States might have as many. Here, however, enters a complicating factor. The occasional or rare species in the majority of the tropical rain forest types make up a significant percentage of the total. There are not only a great many of these

* The term is used loosely here to apply both to rain forests and to moist evergreen forests.

rare species, but they also occur with varying frequency in different parts of the same or similar type of forest. Thus, it is the usual practice to consider the frequency and value of only the predominant species, except for a few rare kinds which are particularly valuable (e.g., mahogany and rosewood). This procedure appreciably lowers the usable volume per acre.

There seems to be little chance of successful pulpwood operation in the more heterogeneous types of tropical evergreen forests. Until a universal pulping process is developed which will utilize all kinds of wood, the possibility of harvesting sufficient volume per acre appears remote. The most practicable operation in forests of this type would appear to require complete removal of the existing forest stand and replacement with one or two planted species. The traditional practice of shifting cultivation is being used to a limited extent to obtain such clearing and planting. As most of this farming is of one to two years' duration, the rate of timber removal is significant in populated regions.

An additional detriment in the use of the mixed tropical hardwood forest for pulp production is the forestry aspect of continued reproduction. In most of the forests there are one or two tiers of smaller trees below the dominants. Even in forests which are composed predominantly of a single species there are scattered individuals (often large) of other species. The second generation, therefore, is often difficult to determine and commonly impossible to control advantageously.

One solution to the exploitation of mixed evergreen forests is multiple usage. With a wide variety of wood properties represented among the species, the manufacture of a variety of products would make most efficient use of the forest. It is not unreasonable to assume that a mixed tropical hardwood forest could be cut for pulpwood, lumber, veneer logs, piling, and railroad ties. Such a combined operation would distribute the cost of transportation facilities and reduce the logging costs inherent in forests with a comparatively low volume per acre. Unfortunately, most companies are not interested in such a diversified enterprise and few are capable of finding profitable uses for a large number of tropical hardwoods.

There are certain natural forest types within the tropical evergreen forests in which a single species constitutes a major part of the wood volume. A few of these offer interesting possibilities for pulp production. The woods of some have been tested in the past, generally with discouraging results. Despite this, anyone interested in the exploitation of tropical hardwood for pulp would be well advised to attempt to overcome the pulping deficiencies of species which are locally very abundant, rather than to search for comparatively rare species with good pulping possibilities.

Considerable areas of new land are formed on bars and deltas in some large tropical rivers. The trees which spring up on these have been suggested as a source of pulpwood, although it is not definitely known whether there is sufficient volume and whether the woods are suitable for pulping.

In most moist tropical regions cleared land that has been abandoned or neglected is quickly covered by a heavy growth of trees, brush, and vines in varying proportions. Most of these plants grow very rapidly but, with a few exceptions, do not generally attain any great size. The rapidity of growth and ability to grow well in the open suggests that these areas might be subjected to clear cutting for pulp. Unfortunately, there is usually a mixture of species varying widely in wood properties. A number of the woods are light and soft, indicating a low unit volume yield, and often possess short fibers, even if their properties are satisfactory. Moreover, there is the problem of losing the tract to, or expensively combating, the adventitious vines that choke all growth in many areas, particularly those with poor soil or which have suffered repeated clearing or burning. In few areas will it prove practicable to manage or harvest for pulp the natural growth that follows agriculture or other clear-cutting operations.

Although not all the variants and possibilities have been considered here, it is evident that only a limited number of the evergreen tropical hardwood forest types are at all suitable for the production of paper pulp by methods in use today. Where large volumes of one or more species having suitable technical properties occur over a limited area, the natural forest may be used to produce pulpwood, at least for one crop. The alternative is the establishment of plantations of one or more hardwood species. These will presumably be rapidly growing types, such as those which characteristically encroach on abandoned land. On fairly good soil with selected species, it is not unreasonable to expect an average diameter growth of 1 inch per year and the theoretical productivity per acre will be very high. Poor soil or unsuitable moisture conditions will drastically reduce the rate of growth in the tropics, as elsewhere.

When the species has been selected the operator will probably be faced with the problem of establishing a nursery, raising seedling stock, and conducting planting and cultural operations with little, if any, information or experience to guide him. Control of diseases, insects, and competitive plants will be problems of the moment; fortunately, recently developed chemicals give material aid in this phase of the work. Also, the extremely rapid growth will permit early observations and, therefore, a more rapid accumulation of experience. There appear to be great possibilities in the production of cellulose or pulp with rapid-growing planted tropical hardwoods; among the hundreds of promising species that have not been tested are probably several excellent producers.

One important factor will be the labor involved in clearing areas or lines for planting and for the protection of planted stock during the first two years. Probably similar cultural work will be advisable to assure survival and to stimulate the growth of seedlings in naturally reproduced forests. Although this type of labor is not costly in tropical regions, the size of the areas to be dealt with and the frequency of clearing required make the operation one of the highest per-acre costs associated with the growing of planted tropical hardwoods. Sprays or other applications of chemicals may prove economical methods of controlling invading vegetation in certain instances, but often these will be more costly than manual operations with the machete.

There is a practical approach to the utilization of an existing tropical hardwood forest for pulp and for obtaining successive cuttings from the same area. As the

initial cutting proceeds, the entire area is cleared of vegetation; it should probably be thoroughly burned. Perhaps some of this clearing and burning operation can be carried out without direct charge by permitting villagers to grow one crop of maize on the cutover land. (This practice would deplete already poor soil and might seriously shorten the life of the operation.) Following clearing, seedling stock would be planted and protected for two years. Such an operation would probably require the establishment of a nursery prior to cutting. A period of research into nursery and planting practices might be necessary to ensure success. The species would then have to be selected for planting and seeds or "cutting slips" obtained a year before beginning harvesting the pulpwood. However, if carefully planned and organized, an operation combining the cutting of old growth timber and complete replanting should prove successful in tropical hardwood regions.

Bamboo and Palms

The use of bamboo as a source of pulpwood has many advocates. Among its advantages is the continuing production of stems for harvest, eliminating the need for replanting. One serious difficulty is that of obtaining sufficient plants to start operations on a large scale. A further obstacle is the 5-year period which must elapse before the first cutting. The large gross volume of stems per unit weight or volume of cellulose may add to production costs. In spite of these deterrents, bamboo must always be considered in any proposed program for the production of pulpwood in tropical regions.

Hundreds of species of palms occur, often abundantly, in the tropics. Some kinds grow rapidly and either close together or to large dimensions. Their woods vary from soft and spongy to extremely hard and heavy, sometimes with a density greater than that of water. Characteristically, the logs have a soft inner core and a harder outer shell. The wood is composed of long, very hard strands of fibers embedded in a tissue of short parenchymatous cells. It is the abundance and spacing of these strands that cause most of the density variation in the log and among the species of palm. In lower density wood, the amount of long-fibered material obtained would constitute only a small percentage of the total volume of material. Certain species of palms could presumably be grown for their wood just as some are now grown for oil, dates, and coconuts.

DETERIORATION OF PULPWOOD

In tropical regions, and particularly during rainy periods, the rate of sapwood deterioration from stain, decay, and insects is extraordinarily high. Water storage might be a partial answer, although brackish water must be avoided. Water spraying is probably not sufficiently effective. Certain chemical sprays or dips will control the insects and reduce stain if they are not too expensive for this application. The best solution would seem to be utilization very soon after cutting.

SEASONAL CONSIDERATION

Throughout the tropics there is a general belief that logging cannot be done during the rainy season. The extremely heavy rainfall, lack of all-weather roads, and the soft character of some soil types make the wet season a formidable obstacle. However, with recent improvements in transportation facilities and equipment, more and more operations are working throughout the year. Better roads, improved bridges, good drainage, clearing of rights-of-way to admit sunlight, etc., are required for road haul. Light rail equipment is economical under certain conditions. Cable skidding should be used to a greater extent. Tractors are frequently used, but full advantage is not made of the attached winch for bunching preparatory to skidding. Vehicles with extra large tires can probably be used in some instances for pulpwood of relatively small diameter. In general, logging during the wet season requires preliminary preparation, the use of special equipment, and ingenuity. Few tropical hardwood forests will be as difficult to log during the rainy season as were the tupelo swamps of the southern United States.

LOCATION OF PULP MILLS

There are many factors in favor of locating the pulp mill in the tropics near the timber. Reduction of volume and weight in shipping is obvious, deterioration of pulpwood will be reduced and costly chemical dips or sprays will be at least partly eliminated, closer scheduling of woods operations is possible, labor costs are lower, tax rates are very favorable. Moreover, a better local political situation is established which is a very important factor. (In most countries, there is a strong feeling against the export of raw material without at least preliminary manufacture in the country of origin. This feeling and the attendant pressures are increasing.) In all but a few countries, foreign investments in manufacturing enterprises are encouraged and protected and, if it is possible to include one or more carefully selected residents of the country as stockholders or subcontractors, the position of the company can be very strong.

Weighing against the establishment of a pulp mill in tropical regions are equally imposing deterrents. There is always the reluctance to make larger than necessary investments in a foreign country. Lack of familiarity with the language and customs of the people is a real obstacle. Technical men and supervisors require larger salary and other compensations for working in tropical countries. (Lower living costs and tax advantages partially offset this. Rapid air transport at reasonable rates has further reduced the objections.) There is insufficient knowledge of the properties of the woods, the processing methods best adapted to each species, and the life habits and methods of handling forests and trees. Fear of political upheaval or entanglement resulting in unreasonable costs, or even expropriation, is undoubtedly the single factor which is most retarding the development of tropical resources.

A logical sequence for the development of a source of tropical pulpwood might be as follows. First, is the study of various locations, forests, and land types and the selection of one. The second is the obtaining of a concession, contracting for the timber, or purchase of the area. Simultaneously, arrangements for taxes and liabilities should be agreed upon with the government—additional stated benefits to accrue when a pulp mill is established. Third, if planting is involved, a nursery

should be started and experiments conducted. A properly balanced area will permit five years of nursery development before the first plantings are made. Fourth, installation of equipment, transportation facilities, etc. Fifth, commencement of operations. Initially, the pulpwood would be sent to an established mill and, eventually, if everything went well, a mill would be built near the wood source.

The economic and technical problems of tropical wood utilization are great but not insurmountable. The manufacture of pulp from these sources is entirely practical if careful and comprehensive planning, technical control, and judicious diplomacy are practiced.

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The Physical Properties of Tropical Woods

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For the most part the information that has been accumulated on the physical properties of wood is based upon studies of species native to the temperate zones. Although each of these species is characterized by its individual combination of physical properties, it has been found, in general, that density or specific gravity is the most satisfactory single criterion indicative of many other physical properties of wood. This is not surprising, inasmuch as the wood substance of the cell wall is believed to be the same for all woods. Specific gravity is thus an expression of the relative amount of wood substance present per unit volume. In addition to its direct value as a measure of weight, specific gravity is related to most mechanical and elastic properties, shrinkage, thermal conductivity, electrical capacity, permeability, and void volume or capacity to hold liquids.

A complete discussion of the physical properties of all tropical woods is beyond the scope of this paper. An attempt will be made rather to compare a substantial number of tropical woods with a representative group of temperate-zone woods on the basis of specific gravity. Illustrations are given to show to what extent a limited number of tropical woods differ from temperate woods in a few selected mechanical properties of interest with respect to utilization for pulp and paper. Particular attention is called to comparisons with temperate-zone species now utilized as pulpwoods.

Discussion of the characteristics of tropical woods is handicapped by the relative incompleteness of our knowledge of the vast number of woods native to the tropics as compared with the more thorough testing which has been conducted on the less numerous woods of the temperate zones. A further difficulty is encountered as a consequence of the lack of uniformity of test methods which have been employed in the various research laboratories that have been engaged in studies of tropical woods.

Even the compilation of results from such a relatively simple test as determination of specific gravity involves possible confusion and a considerable amount of recalculation. Figure 1 shows the specific gravity distribution for 330 woods from tropical America, Africa, and the Philippines as compared with that for 168 woods of the United States. In this diagram specific gravity is expressed on the basis of oven-dry weight and green volume.

The data for tropical woods were derived from several sources (*1*) and were available in several forms. All the data on domestic woods were collected at the Forest Products Laboratory, Madison, Wis. In one case, the essential information was presented as weight in pounds per cubic foot at 12% moisture content. Since shrinkage values from the green to air-dry conditions (12% moisture) were also given, specific gravity was computed by reducing weight to oven-dry weight, adjusting the volume to correspond to the green condition, and comparing the resulting weight per cubic foot with that of water.

In another instance, published values for specific gravity were expressed on the basis of weight (grams) per unit of volume (cubic centimeter), both at 15% moisture content. Since a volumetric shrinkage coefficient per 1% moisture content change was also presented, it was possible (assuming a 25% fiber saturation point) to adjust these values to the desired basis.

It is conventional in the United States to use *oven-dry weight* and either green volume, oven-dry volume, or volume at a specified moisture content in expressing specific gravity; therefore, no adjustment was required for data on woods tested here or in the Philippines. Relationships between various physical properties (other than weight per unit volume) and specific gravity have little general application unless based upon oven-dry weight. Only in this way is a measure of the amount of wood substance per unit volume, as distinguished from the combined weight of wood and moisture, obtainable. Weights per cubic foot or other unit of volume are readily computed from these specific gravity values when the percentage moisture content is specified.

As shown in Fig. 1 which indicates specific gravity distribution by number of species, tropical woods exhibit a somewhat wider range of specific gravity than do the temperate woods tested—ranging from the 0.20 to 1.00 specific gravity classes. The tropical woods are heavily represented percentagewise from the 0.40 to 0.80 specific gravity classes, whereas comparable frequencies of occurrence are shown for temperate woods in the 0.30 to 0.60 classes of specific gravity.

Only 10 of the 330 tropical species represented in Fig. 1 are softwoods. These species are uniformly distributed throughout the range of 0.32 to 0.62 in

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Table I. Mechanical Properties of Tropical Woods in the Green and Air-Dry Conditions[a]

(Air-Dry Values Adjusted to 12% Moisture Content)

Species	Source	No. of logs	Moisture content, %	Specific gravity: Oven-dry vol.	Specific gravity: Green vol.	Static bending: Fiber stress at proportional limit, p.s.i.	Static bending: Modulus of rupture, p.s.i.	Static bending: Modulus of elasticity, 1000 p.s.i.	Static bending: Work to proportional limit, in.-lb./cu. in.	Static bending: Work to maximum load, in.-lb./cu. in.	Compression parallel to grain: Fiber stress at proportional limit, p.s.i.	Compression parallel to grain: Maximum crushing strength, p.s.i.	Compression parallel to grain: Modulus of elasticity, 1000 p.s.i.	Hardness: End, lb.	Hardness: Side, lb.	Compression perpendicular to grain, stress at proportional limit, p.s.i.	Tension perpendicular to grain, p.s.i.	Shear, p.s.i.	Cleavage, lb./in. of width	Toughness,[b] in.-lb./specimen
Almendro (*Coumarouna oleifera*) (*Coumarouna odorata*)	Panama Brazil	4	46.7	1.02	0.89	12,160	17,950	2690	3.14	12.2	6460	8,600	2800	2200	2380	1970	1080	1660	480	255.2
Bulletwood (*Manilkara bidentata*)	Surinam	7	47.6	1.03	0.85	11,120	17,310	2700	2.51	13.6	7030	8,690	3060	2160	2230	2480	990	1900	480	264.8
	British Guiana		13.2	..	..	15,030	27,280	3450	3.76	28.5	8050	11,640	3360	2650	3190	2320	1100	2500	330	...
	Puerto Rico																			
Guayacán (*Tabebuia guayacan*)	Honduras	3	35.4	1.00	0.85	11,060	18,480	2580	2.71	18.7	7730	9,740	2910	2820	3140	2390	990	2230	510	286.3
			13.5	..	..	14,990	26,320	3060	4.14	22.7	7670	12,730	3170	3240	3350	2400	780	2720	460	...
Goncalo alves (*Astronium graveolens*)	Honduras	4	46.2	0.95	0.84	8,510	12,140	1940	2.28	6.7	4620	6,580	2230	1640	1910	1840	1000	1760	420	139.0
	Venezuela		13.4	..	..	11,320	16,620	2230	3.34	10.4	7800	10,320	2620	2020	2160	2110	840	1960	440	...
Black kakeralli (*Eschweilera sagotiana*)	British Guiana	2	50.7	0.98	0.82	10,680	17,780	2910	2.28	13.4	6170	7,780	2880	2000	2480	1580	560	1790	390	264.5
			14.2	..	..	12,860	23,420	3250	2.84	24.4	5930	11,200	3750	2760	2780	1530	860	2250	300	...
Guayacán (*Tabebuia heterotricha*)	Panama	3	40.5	0.91	0.80	10,880	20,080	2120	3.31	27.3	6600	7,680	2540	2270	2530	1430	1170	2140	490	343.0
Muira-juba (*Apuleia molaris*)	Brazil	2	55.0	0.86	0.76	9,800	15,360	2180	2.50	13.4	6100	7,330	2480	1780	2060	1690	1180	1860	560	277.3
			12.1	..	..	14,470	20,960	2510	4.62	20.4	7240	10,030	2480	1880	2280	2040	1130	1970	510	...
Piquia (*Caryocar villosum*)	Brazil	3+	61.3	0.84	0.72	8,260	12,450	1820	2.17	8.4	4990	6,290	2210	1450	1720	2080	990	1600	430	150.5
			13.8	..	..	10,990	17,060	2160	3.07	15.8	5140	8,410	2260	1620	1720	1620	780	1990	380	...
Mylady (*Aspidosperma cruentum*)	British Honduras	3	57.2	0.82	0.71	9,070	14,100	2500	1.83	8.9	5360	6,650	2840	1500	1470	1100	760	1500	420	152.8
			11.4	..	..	14,150	20,790	2760	4.12	16.9	8380	11,110	3270	1950	1490	1320	460	1700	260	...
Mora amarilla (*Chlorophora tinctoria*)	Guatemala	4	64.7	0.77	0.71	9,320	14,840	1590	3.45	14.4	4860	6,860	1690	2080	2190	1800	1030	1850	450	229.3
	Honduras																			
	Venezuela																			
Courbaril (*Hymenaea courbaril*)	Honduras[c]	6	59.9	0.80	0.70	6,890	12,180	1640	1.62	14.1	3820	5,340	1770	1780	1970	1810	1290	1800	570	214.6
	Surinam		12.4	..	..	10,160	17,400	1900	3.01	17.8	5570	8,600	1960	2460	2320	1760	1020	2700	470	...
	Puerto Rico																			
(*Hymenaea davisii*)	British Guiana	3	64.8	0.79	0.67	8,230	12,440	2080	1.62	8.5	4260	5,540	2450	1480	1610	1120	890	1680	410	187.8
			12.1	..	..	10,720	19,290	2950	2.30	19.3	6430	9,400	3170	2070	1760	1230	860	2130	390	...
Chupón (*Pouteria carabobensis*)	Venezuela	3	63.8	0.81	0.68	5,490	11,420	1740	1.02	12.9	2900	4,360	1820	1470	1440	1200	1250	1480	580	235.5
Tatajuba (*Bagassa guianensis*)	Brazil	2+	58.0	0.76	0.68	10,340	14,510	2300	2.84	11.3	6060	7,900	2510	1620	1670	1200	650	1670	370	195.5
			12.0	..	..	13,900	20,050	2580	4.18	14.4	9670	11,560	2850	2140	1730	1690	740	1940	290	...
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	60.5	0.80	0.67	7,600	12,300	1650	1.96	10.0	4230	5,460	1730	1740	1760	950	1230	1700	590	222.8
			11.2	..	..	10,650	16,090	1890	3.40	13.3	5490	8,380	2300	2570	2150	1730	760	1770	400	...
Nargusta (*Terminalia amazonia*)	British Guiana	9	72.3	0.76	0.66	8,140	12,720	2160	1.79	11.4	4700	5,960	2460	1460	1440	1260	880	1500	420	203.0
	British Honduras		12.9	..	..	11,360	17,870	2310	3.16	15.1	6920	9,540	2510	1980	1620	1230	660	1980	260	...
	Panama[d]																			
Carabali (*Albizzia caribaea*)	Venezuela	3	78.3	0.73	0.66	5,820	11,210	1560	1.26	8.4	3420	4,830	1670	1320	1370	1540	840	1500	400	195.9
			12.3	..	..	9,070	14,480	1470	2.57	13.6	4360	7,220	1980	1480	1330	1070	780	1710	380	...
Brazilian louro (*Aniba* cf. *riparia*) (*Aniba duckei*) (*Ocotea sp.*)	Brazil	3	54.6	0.71	0.62	9,960	13,250	2170	2.60	9.7	5680	6,560	2550	1160	1170	1060	750	1420	430	175.8
			13.5	..	..	11,760	19,030	2570	3.12	18.0	7910	10,010	2600	1430	1470	1110	540	1840	280	...
Angélique (*Dicorynia paraensis*)	Surinam	2	78.7	0.69	0.60	7,650	11,410	1840	1.78	12.0	4810	5,590	2180	1100	1100	1000	700	1340	340	151.2
			11.8	..	..	11,610	17,390	2190	3.33	15.2	6810	8,770	2490	1700	1290	1280	560	1660	360	...
Yellow sanders (*Buchenavia capitata*)	Puerto Rico	3	65.1	0.66	0.60	6,330	10,050	1460	1.62	8.8	3790	5,130	1570	1350	1230	1070	800	1340	400	122.8
			14.2	..	..	7,670	12,970	1650	2.04	8.2	5200	7,440	1700	1330	1220	1280	460	1870	290	...
Brazil nut (*Bertholletia excelsa*)	Brazil	2	69.9	0.66	0.59	5,280	9,740	1610	1.01	8.4	3250	4,530	1280	1000	940	850	680	1140	310	143.3
			13.9	..	..	8,480	14,680	1760	2.05	15.3	4750	6,890	1750	1330	1150	890	620	1380	310	...
Sangre (*Pterocarpus vernalis*)	Venezuela	3	62.0	0.65	0.57	5,600	9,580	1580	1.13	8.9	3040	4,140	1820	1020	980	920	900	1220	460	221.3
Guayabo de monte (*Terminalia guyanensis*)	Venezuela	3	73.6	0.62	0.57	5,780	9,400	1330	1.44	7.8	3000	4,240	1380	1110	960	700	790	1230	340	102.3
Fiddlewood (*Vitex gaumeri*)	British Honduras	3	42.5	0.64	0.56	6,170	10,190	1600	1.33	9.9	3240	4,750	1870	1180	1040	790	1140	1310	450	151.0
			12.7	..	..	11,720	16,550	1960	3.65	11.1	5740	8,690	2140	1700	1390	1100	470	1700	320	...
Angelino aceituno (*Nectandra concinna*)	Venezuela	2	88.0	0.63	0.56	5,830	10,440	1540	1.26	10.4	3660	5,020	1680	1020	930	710	1020	1460	430	122.6
			12.8	..	..	9,580	14,230	1650	3.12	12.4	4720	7,260	1880	1170	1060	1140	1070	1460	440	...

Table I. Mechanical Properties of Tropical Woods in the Green and Air-Dry Conditions[a] (*continued*)

(Air-Dry Values Adjusted to 12% Moisture Content)

Species	Source	No. of logs	Moisture content, %	Specific gravity: Oven-dry vol.	Specific gravity: Green vol.	Static bending: Fiber stress at proportional limit, p.s.i.	Static bending: Modulus of rupture, p.s.i.	Static bending: Modulus of elasticity, 1000 p.s.i.	Static bending: Work to proportional limit, in.-lb./cu. in.	Static bending: Work to maximum load, in.-lb./cu. in.	Compression parallel to grain: Fiber stress at proportional limit, p.s.i.	Compression parallel to grain: Maximum crushing strength, p.s.i.	Compression parallel to grain: Modulus of elasticity, 1000 p.s.i.	Hardness: End, lb.	Hardness: Side, lb.	Compression perpendicular to grain, stress at proportional limit, p.s.i.	Tension perpendicular to grain, p.s.i.	Shear, p.s.i.	Cleavage, lb./in. of width	Toughness,[b] in.-lb./specimen
Hububalli	British Guiana	4	98.4	0.62	0.56	5,740	9,380	1680	1.20	7.6	3790	4,700	1920	960	1040	880	630	1200	370	110.8
(*Lozopterygium sagotii*)	Surinam		12.4	..	..	9,900	13,660	1750	3.18	10.6	5540	7,420	2080	1020	1040	900	640	1430	340	...
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	60.4	0.62	0.56	4,920	8,190	1200	1.11	9.2	2790	3,930	1410	1060	1030	960	710	1270	310	130.3
Determa (*Ocotea rubra*)	Surinam	2	75.2	0.62	0.56	6,360	8,810	1650	1.42	5.2	3620	4,380	2070	540	600	700	640	910	320	74.9
Teak (plantation-grown) (*Tectona grandis*)	Honduras	3	72.3	0.59	0.56	6,160	9,940	1350	1.59	10.9	3960	4,780	1350	1140	1290	1290	940	1730	390	116.2
Ocote pine (*Pinus oocarpa*)	Honduras	3	40.6	0.61	0.55	5,060	7,970	1740	0.84	6.9	2580	3,690	1920	530	580	530	380	1040	220	119.9
Andiroba (*Carapa guianensis*)	Brazil	4	65.0	0.60	0.54	6,640	10,300	1690	1.48	9.8	4040	4,780	1720	940	880	730	560	1220	340	112.0
(*Carapa procera*)	Surinam		13.0	..	..	10,240	15,540	2000	2.84	14.0	6080	8,120	2240	1500	1130	830	440	1510	240	...
Flor azul (*Vitex kuylenii*)	Honduras	4	98.8	0.60	0.53	5,860	9,420	1490	1.29	7.7	3700	4,780	1780	1050	1050	1180	650	1280	320	108.0
Rajate bien (*Vitex cooperi*)	Guatemala		13.8	..	..	8,720	12,890	1570	2.55	9.0	5450	7,010	1680	1330	960	990	400	1540	280	...
Roble blanco	British Honduras	6	67.8	0.58	0.52	6,140	10,460	1370	1.54	11.2	3860	4,720	1520	1100	960	860	800	1290	410	152.3
(*Tabebuia pentaphylla*)	Honduras[c]		13.5	...	...	8,870	14,050	1500	2.37	16.6	5210	7,260	1580	1560	1140	950	530	1620	260	...
Cedro espino	Honduras	3	86.0	0.58	0.51	4,650	8,060	1380	0.95	7.8	2790	3,690	1520	840	790	660	760	1110	340	116.9
(*Bombacopsis quinata*)			9.5	..	..	8,410	12,160	1550	2.49	10.5	4750	6,620	1830	1190	930	840	380	1320	240	...
Vaco	Panama	3	84.8	0.56	0.50	4,950	8,560	1690	0.84	6.5	2610	3,590	2060	880	860	740	860	1120	410	118.3
(*Magnolia sororum*)			10.8	..	..	9,600	14,250	1970	2.54	10.8	5660	7,850	2140	1580	1090	890	630	1490	280	...
Tauary	Brazil	3	68.9	0.56	0.50	5,390	9,240	1730	0.94	8.3	3390	4,270	2000	840	740	560	660	1070	320	123.9
(*Couratari pulchra*)	British Guiana		13.4	..	..	9,680	13,510	1800	2.88	12.2	5720	7,460	1960	1260	880	860	550	1380	280	...
Gronfoeloe	Surinam	2	151.8	0.56	0.50	5,960	9,050	1670	1.24	6.8	3820	4,790	1940	820	740	680	660	1080	300	96.5
(*Qualea albiflora*)			14.8	..	..	10,350	14,450	1970	3.12	9.4	6790	8,340	2240	1440	910	740	340	1530	270	...
Wiswiskwalie (*Qualea sp.*)																				
Candelera (*Cordia collococca*)	Venezuela	3	87.4	0.54	0.47	4,600	6,970	1350	0.78	4.7	2370	3,510	1410	630	540	380	600	730	260	85.9
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	3	50.7	0.46	0.42	5,080	8,350	1140	1.14	7.3	2730	3,500	1040	1160	1090	1090	750	1500	280	84.3
Laurel blanco	British Honduras[c]	10	122.2	0.46	0.42	5,350	8,720	1170	1.46	9.8	3370	3,910	1310	820	740	700	520	1090	270	131.7
(*Cordia alliodora*)	Honduras[c]		12.1	..	..	6,190	10,690	1300	1.69	11.1	4350	5,370	1290	820	590	590	390	1130	240	...
	Nicaragua																			
Cedro granadino	Panama	3	67.4	0.46	0.41	4,520	7,510	1310	0.94	7.1	2770	3,370	1330	650	550	600	430	990	260	106.2
(*Cedrela tonduzii*)			11.8	..	..	7,940	11,530	1440	2.45	9.4	5130	6,210	1540	940	600	660	350	1100	225	...
Espavé	Panama	6	109.0	0.44	0.41	3,200	5,320	1060	0.62	4.1	1710	2,460	1200	410	400	360	370	740	190	57.3
(*Anacardium excelsum*)	Venezuela																			
Cativo	Panama	3	81.2	0.44	0.40	3,240	5,920	940	0.57	5.4	1610	2,460	1020	460	440	450	460	860	210	88.4
(*Prioria copaifera*)			10.9	..	..	6,070	8,560	1110	1.85	7.2	2920	4,290	1070	830	630	520	420	1060	220	...
Primavera (*Tabebuiadonnell smithii*)	Honduras	3	56.2	0.44	0.40	4,170	7,180	990	0.99	7.2	2850	3,510	1050	810	700	800	720	1030	320	74.8
Cedro branco	Brazil	2	83.8	0.41	0.38	4,020	6,730	1170	0.80	7.4	2220	3,100	1340	460	450	390	450	790	260	82.2
(*Cedrela huberi*)			16.4	..	..	7,300	11,300	1420	2.08	12.5	5260	6,010	1460	790	570	710	390	1200	250	...
Possumwood	Panama[c]	7	67.2	0.41	0.38	3,930	6,310	1040	0.89	6.5	1960	2,790	1170	520	440	420	580	830	300	70.4
(*Hura crepitans*)	Surinam		12.0	..	..	5,660	9,050	1120	1.46	6.3	3750	5,130	1270	920	600	750	260	1270	280	...
	Venezuela[c]																			
Simaruba	Surinam	2	69.2	0.40	0.38	3,900	6,310	1140	0.76	4.5	2340	2,970	1240	510	390	380	560	790	230	65.8
(*Simaruba amara*)			12.2	..	..	6,280	8,930	1240	1.78	5.8	3690	4,840	1360	790	440	600	390	1160	250	...
Quaruba	Brazil	5	191.9	0.42	0.37	3,970	6,120	1220	0.75	5.2	2080	2,760	1440	670	610	400	430	740	210	96.9
(*Vochysia guianensis*)	Surinam		12.5	..	..	6,130	9,090	1390	1.53	6.7	4700	5,840	1550	630	530	670	350	980	190	...
(*Vochysia hondurensis*)	Nicaragua																			

[a] All tests made according to American Society for Testing Materials Standard Method D143–48.

[b] Based on a specimen 5/8 by 5/8 by 10 inches tested over an 8-inch span with load applied to the tangential face. The toughness value shown represents an average of tests conducted on both green and air-dry material since no consistent differences were shown between toughness values obtained in these two conditions.

[c] Air-dry strength data not yet available from this source.

[d] This source not represented by green strength data.

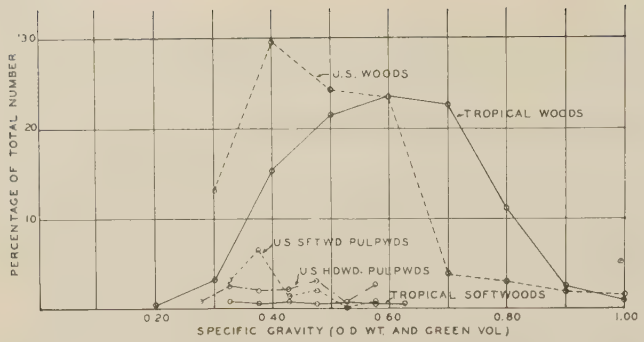

Fig. 1. Specific gravity distribution for 330 tropical woods from Central and South America, Africa, and the Philippines and 168 woods native to the United States. Frequency diagrams for tropical softwoods and U. S.-grown pulpwoods are also shown

specific gravity. Softwoods constitute a much higher proportion of the total number of temperate wood species. The frequency diagram in Fig. 1 is limited to 22 softwood species used for pulp and paper and indicates that most of these woods are between 0.32 and 0.42 in specific gravity. Twenty-one temperate hardwoods used for pulp and paper are shown to range from 0.28 to 0.58 in specific gravity. Within this range, it would appear that pulping experience acquired from temperate hardwoods would have some applicability to tropical hardwoods.

An obvious application of specific gravity data based on green volume is the estimation of green weights per cubic foot or other units of volume. Because of the wide variability in moisture content of green logs, even woods of relatively low specific gravity may have weights in excess of 62.4 pounds per cubic foot required for flotation. In computing weight per cubic foot, specific gravity is simply multiplied by 1 + moisture content percentage* (expressed as a decimal) and further multiplied by 62.4. Thus, a wood with specific gravity of 0.50 and 60% moisture content weighs $0.50 \times 1.60 \times 62.4 = 49.9$ pounds per cubic foot.

The moisture content of unseasoned wood of about 75 Tropical American species has been found to range from 35 to 192% (*1c, 1d*). Representing practically the entire range of density for which data are available, these tropical woods vary from 38 to 82 pounds per cubic foot in the green condition. Examination of the data, part of which are contained in Table I, shows there are *some* woods in all specific gravity classes 0.40 and above that exceed 62.4 pounds per cubic foot in weight. Above 0.70 specific gravity, *all* these woods show green weights in excess of 62.4 pounds per cubic foot.

The Yale School of Forestry has been conducting an intensive study of the mechanical properties of Tropical American woods since 1947.† Table I shows green and air-dry strength properties so far as available for 48 of these woods. Specific gravity and original log moisture content values are also presented.

Of the mechanical and elastic properties shown in the table, three are of particular interest from the standpoint of fiber utilization; their relationships with specific gravity are compared with those for temperate woods in Figs. 2 to 4. Modulus of rupture, derived from static bending tests, is a conservative measure of tensile strength parallel to the grain. Modulus of elasticity in static bending is a measure of the stiffness of wood. Both these properties of wood are dependent ultimately upon the properties of the individual fibers and, hence, should be of some value in characterizing the fiber qualities of a wood. Admittedly, there are factors of fiber orientation and of fiber-to-fiber bonding that may tend to modify the properties of the fibers themselves. Shear strength has been shown to be a factor in power consumption involved in the chipping of wood (*2*). Data from mechanical tests conducted at the University of Michigan on a number of Tropical American, African, and Philippine woods are plotted in these figures together with Yale data for Tropical American species.

In Fig. 2 modulus of rupture of tropical woods is plotted against specific gravity for both the green and air-dry conditions. The curves are those derived by the Forest Products Laboratory on the basis of tests of 168 domestic species. It is clearly evident that the averages of plotted points representing the strength of green wood lie above the Forest Products Laboratory curve throughout the entire range of specific gravity, exceeding the curve by as much as 25% toward the upper limits of specific gravity. The improvement in

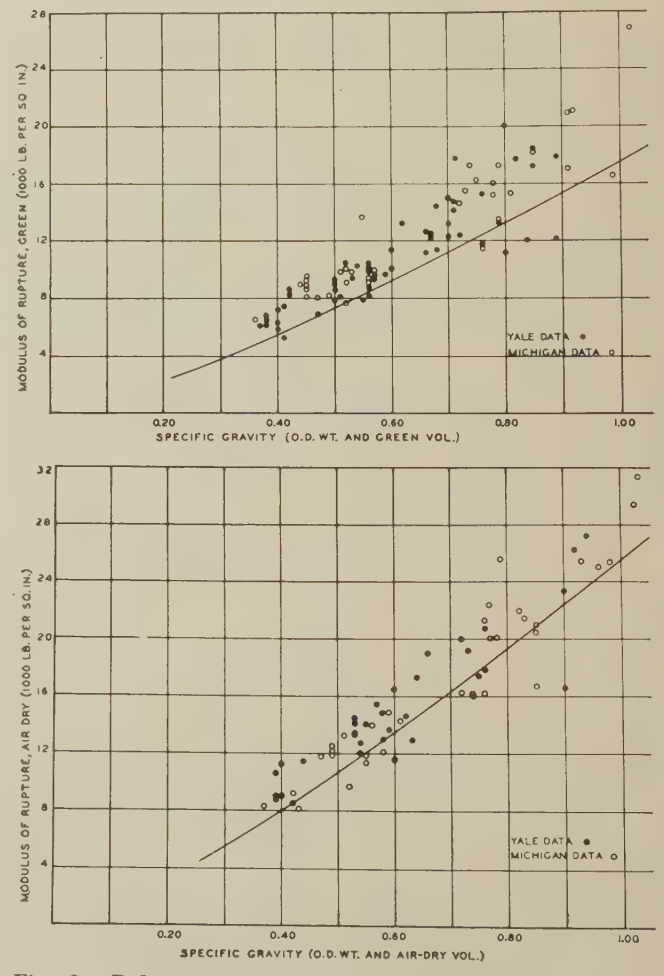

Fig. 2. Relationship between modulus of rupture and specific gravity for green and air-dry tropical woods compared with U. S. woods. (Curve representing U. S. woods prepared from data of the Forest Products Laboratory)

* Moisture content is commonly expressed in wood technology practice as a percentage of oven-dry weight.

† These tests have been conducted under a program sponsored by the Office of Naval Research and Bureau of Ships, United States Department of the Navy.

strength obtained through seasoning is shown in the graph for air-dry wood but, in this condition, the similarity to the strength-specific gravity relationship for domestic woods is much more evident than in the case of green wood. Insofar as generalizations are permitted it appears that the air-dry curve derived for domestic woods is reasonably applicable to tropical woods as well. An explanation for this difference in behavior of green and air-dry woods has been suggested by the writer, based primarily on evidence that these tropical woods are characterized by a lower fiber saturation point than are the majority of domestic woods (*3*).

The modulus of elasticity-specific gravity relationship is shown in Fig. 3. The plotted data for green wood again show a general trend-line steeper than that derived for domestic woods. At the upper limits of specific gravity, an average of the plotted data exceeds the domestic wood curve by at least 30%. In the air-dry condition the same situation prevails to a somewhat less pronounced degree, values for the denser woods exceeding the curve by 15 to 20%.

On the basis of these results, tropical woods may be considered generally to equal or exceed domestic or temperate-zone woods of the same density in both

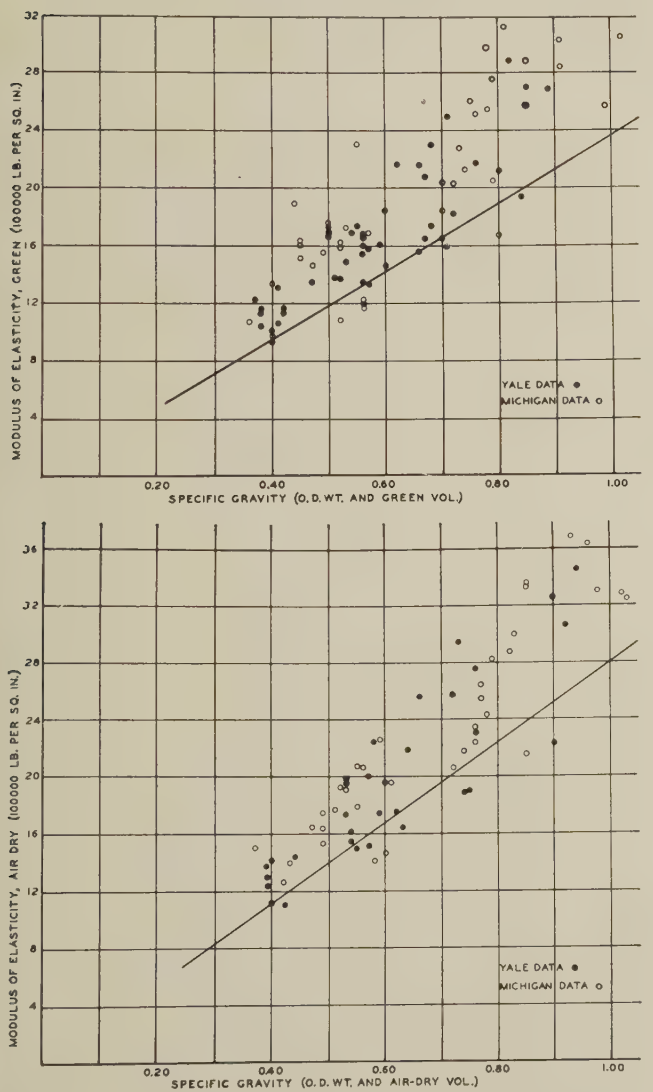
MODULUS OF ELASTICITY, GREEN (100000 LB. PER SQ. IN.)
SPECIFIC GRAVITY (O.D. WT. AND GREEN VOL.)
YALE DATA
MICHIGAN DATA
MODULUS OF ELASTICITY, AIR DRY (100000 LB. PER SQ. IN.)
SPECIFIC GRAVITY (O.D. WT. AND AIR-DRY VOL.)
YALE DATA
MICHIGAN DATA

Fig. 3. Relationship between modulus of elasticity and specific gravity for green and air-dry tropical woods compared with U. S. woods. (Curve representing U. S. woods prepared from data of the Forest Products Laboratory)

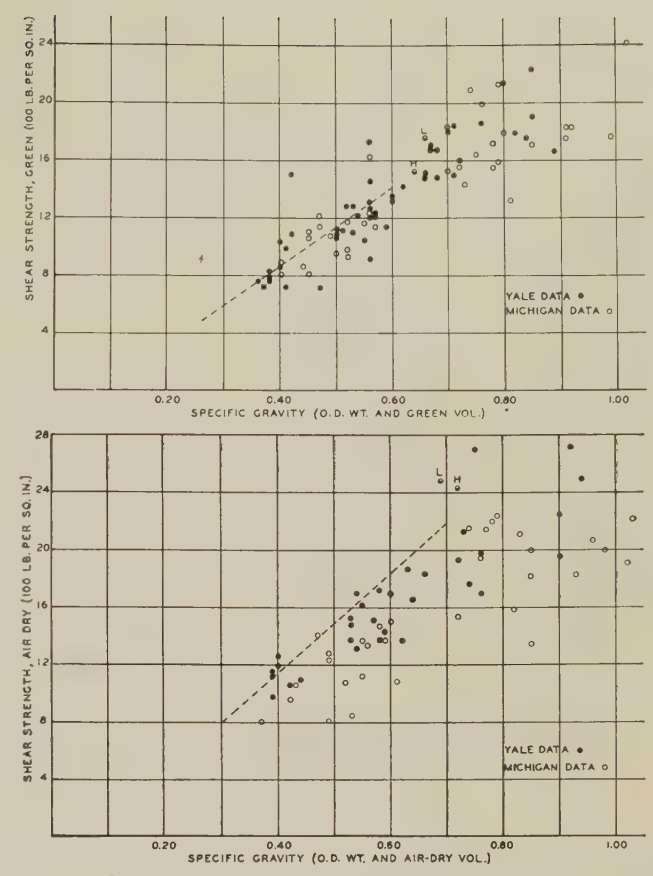
SHEAR STRENGTH, GREEN (100 LB. PER SQ. IN.)
SPECIFIC GRAVITY (O.D. WT. AND GREEN VOL.)
YALE DATA
MICHIGAN DATA
SHEAR STRENGTH, AIR DRY (100 LB. PER SQ. IN.)
SPECIFIC GRAVITY (O.D. WT. AND AIR-DRY VOL.)
YALE DATA
MICHIGAN DATA

Fig. 4. Relationship between shear strength and specific gravity for green and air-dry tropical woods. (The trend line for U. S. pulpwoods is based upon Forest Products Laboratory data for 21 hardwood species commonly used as pulpwood.) Data for black locust (L) and shagbark hickory (H) are also shown for comparison

tensile strength and stiffness. The superiority of the tropical woods is particularly evident in the green condition. Such generalizations, of course, fail to apply to any particular species. Insofar as the species listed in Table I are concerned, the relative position of individual species can be ascertained. Such comparison can, of course, be extended to individual temperate-zone pulpwoods as well from other available data.

Considerable dispersion is shown by shear data for both tropical and domestic woods when plotted against specific gravity. However, as shown in Fig. 4, a general trend toward increasing strength with increasing specific gravity is evident. No regression equation has been published for domestic woods; hence, the absence of a curve for comparison with tropical woods. The broken line shown in Fig. 4 represents the approximate trend shown by the 21 temperate hardwood pulpwoods represented in Fig. 1.

It may readily be seen that, within the limits of specific gravity for which comparison is permitted, the domestic pulpwood curve is reasonably representative of the shear strength of tropical woods in the green condition. Values for shagbark hickory and black locust are shown individually, inasmuch as they represent a quality of wood with which considerable difficulty has been encountered in chipping with usual pulp mill equipment. Tropical woods with specific gravity in excess of 0.65 are apt to be equal to or more refractory than hickory with respect to chipping characteristics in the green condition.

Contrary to their behavior with respect to the other properties illustrated, tropical woods show no general increase in shear strength upon seasoning. When tested in the air-dry condition, they are found to be generally below the trend line representing shear strength of domestic pulpwoods as related to specific gravity. Hence power consumption in chipping these woods when air dry is indicated to be less than that for domestic woods of the same density. Even though many tropical woods exceeding black locust and hickory in specific gravity are included in the comparison, practically all of them showed appreciably lower shear strengths than these heavy domestic woods when tested in the air-dry condition.

It is hoped that the information presented in this paper may be helpful in showing in some degree how tropical woods differ from the more familiar temperate woods in their general physical characteristics, as well as in supplying specific information on a number of woods that may be of interest to this meeting. No attempt has been made to supply data for a group of tropical woods selected particularly because of their potential importance as a source of raw material for pulp and paper. That, of necessity, involves many factors and would require the determination of physical constants for a great many individual species from all parts of the tropics—a task which largely remains to be done.

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The Chemical Characteristics of Tropical Woods

LOUIS E. WISE

Stimulated by the investigations of Wangaard and Hess at Yale University (*1*) and sponsored by the Office of Naval Research, the Institute, two years ago, undertook chemical studies on a limited number of tropical woods. In most instances, these specimens were from the same billets that had been studied (from the standpoint of physical properties and durability) at New Haven, and the sampling of these specimens may be considered fully representative of the woods actually investigated at the Yale School of Forestry. However, it should be stated—emphatically—that our data, although entirely valid for the specimens used in making physical tests at Yale, are limited to composite samples taken from only a small number of logs—in certain instances only from one log. This fact—especially in the light of Cohen's important paper—cannot be overemphasized. In a study such as this, no generalizations regarding species can be made, and any prognoses or hypotheses must be offered only with the greatest reservation. However, certain trends can be pointed out. It is also our object (whenever possible) to compare Institute data with those of others who have concerned themselves with the chemistry of tropical woods. The experimental work in our study was carried out by my colleagues, the Misses Rittenhouse and García, and Messrs. H. Olson and E. E. Dickey. Entomological studies (which are not discussed in this paper) were made by J. B. Anderson.

The greater part of this study was analytical and a part of the data have been reported previously (*2*). It included qualitative determinations of the sugar units in the various woods and tests for starch, alkaloids, and tannins. Quantitative analyses were made for ash (which was also examined spectrographically), extractives, tannin, methoxyl of extracted and unextracted wood, Klason lignin (and the methoxyl in this lignin), methoxyl not in the lignin *or* the extractives, alpha-cellulose (ash, lignin, xylan, uronic anhydride, and in certain instances, mannan in this cellulose), total uronic anhydride, total pentosans (corrected for uronic anhydride and calculated as xylan), mannan (in certain cases), nitrogen, and acetyl content. Whenever the spectrographic analyses indicated appreciable amounts of silica, the latter was determined quantitatively (and when necessary, corrected for boron). Fully recognizing the limitations of the lignin determinations, we followed the method of Freudenberg and Ploetz (*3*), using various strengths of sulphuric acid and choosing as the most probable lignin content that with the highest methoxyl value. These comprehensive analyses were made on woods received from New Haven. A few woods were also obtained through the courtesy of C. H. Edmondson, zoologist of the Bernice P. Bishop Museum of Honolulu, woods which, although extremely interesting, were examined only for ash components (*4*). Certain of the tropical woods were of marked chemical interest because of their resistance to marine borers; in a number of cases these were also quite high in silica. However, there were instances in which teredo-resistant specimens contained very little silica, thus indicating the danger of hasty generalizations.

In most cases, proximate summations of (nonoverlapping) analytical data were made by two different methods, which will be discussed later.

The following woods were studied at the Institute:

Tabebuia guayacan ("guayacan") (representing three logs from trees grown in Honduras).

Pseudosamanea guachapele ("frijolillo") (representing three logs from trees grown in Honduras).

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Ocotea rubra ("determa") (representing two logs from trees grown in Surinam).
Manilkara bidentata ("bulletwood") (representing three logs from trees grown in Puerto Rico).
Manilkara bidentata (representing one log from a tree grown in Surinam).
Cordia alliodora ("laurel blanco") (representing three logs from trees grown in Honduras).
Hymenaea courbaril ("courbaril") (representing two logs from trees grown in Honduras).
Licaria cayennensis ("kaneelhart") (representing one log from a tree grown in Surinam).
Couratari pulchra ("tauary") (representing two logs from trees grown in Brazil and one log from a tree grown in British Guiana).
Eschweilera sagotiana ("black kakeralli") (representing two logs from trees grown in British Guiana).
Dicorynia paraensis ("angelique") (representing two logs from trees grown in Surinam).
Tectona grandis ("teak") (representing one log from a tree grown in Burma).
Swietenia macrophylla ("mahogany") (representing one log from a tree grown in South America).
Ocotea rodiaei ("greenheart") (one block from a tree grown in British Guiana).
Syncarpia laurifolia ("turpentine tree") (Australian)
Syncarpia laurifolia (Hawaiian)
Antidesma pulvinatum (Hawaiian)
} Small samples obtained from C. H. Edmondson.

It might be best at this point to re-emphasize the concepts on which the Institute summations are based. As indicated in our schematic representation (one which has been described in detail in other papers) (Fig. 1), there are two possible ways of defining "alpha-cellulose." If this fraction is isolated analytically (in this case by successive treatments of chlorite holocellulose with potassium hydroxide under nitrogen), then this fraction will retain some sugar units other than glucose. This may be termed *alpha-cellulose*. If, however, alpha-cellulose is defined narrowly as being made up *only* of alkali-resistant *β-D-glucopyranose units*, then a correction must be made for the presence of these other units. This means that xylan, uronic anhydride, etc., must be determined separately in the alpha-cellulose, and the sum of such impurities (based on the initial wood) must be subtracted from the alkali-insoluble fraction. Thus the "cellulose" (or even "alpha-cellulose") may have a dual personality. On the definition of our choice will depend which wood components should be included in a specific summative analysis. Recognizing *both* viewpoints, each of these concepts of alpha-cellulose has been used in our analytical summations. Hence, there are two sets of data (Tables I and II).

Now to come to our two sets of typical summations. In one case we have the interesting tropical wood, determa (*Ocotea rubra*) and in the other a native southern red oak (*Quercus rubra*). The analyses computed on the extractive-free, oven dry basis show marked differences. The tropical wood is much higher in lignin and much lower in hemicelluloses and in acetyl value than is the red oak. The methoxyl content of the lignin was also appreciably lower than that of the oak. Similarly, in the other set of figures (Table II), the xylan content of the tropical wood is the lower of the two. The methoxyl content of the tropical wood, however, was higher than that of most of our common native hardwoods. The alpha-cellulose content was high. Similar trends also were found in some other tropical hardwoods, but not in all of them. Of 14 tropical woods examined at the Institute, 9 gave relatively high lignin values and correspondingly low hemicellulose, acetyl (and xylan) values, varying quite widely from those of most of our native angiosperms. On the other hand, with very few excep-

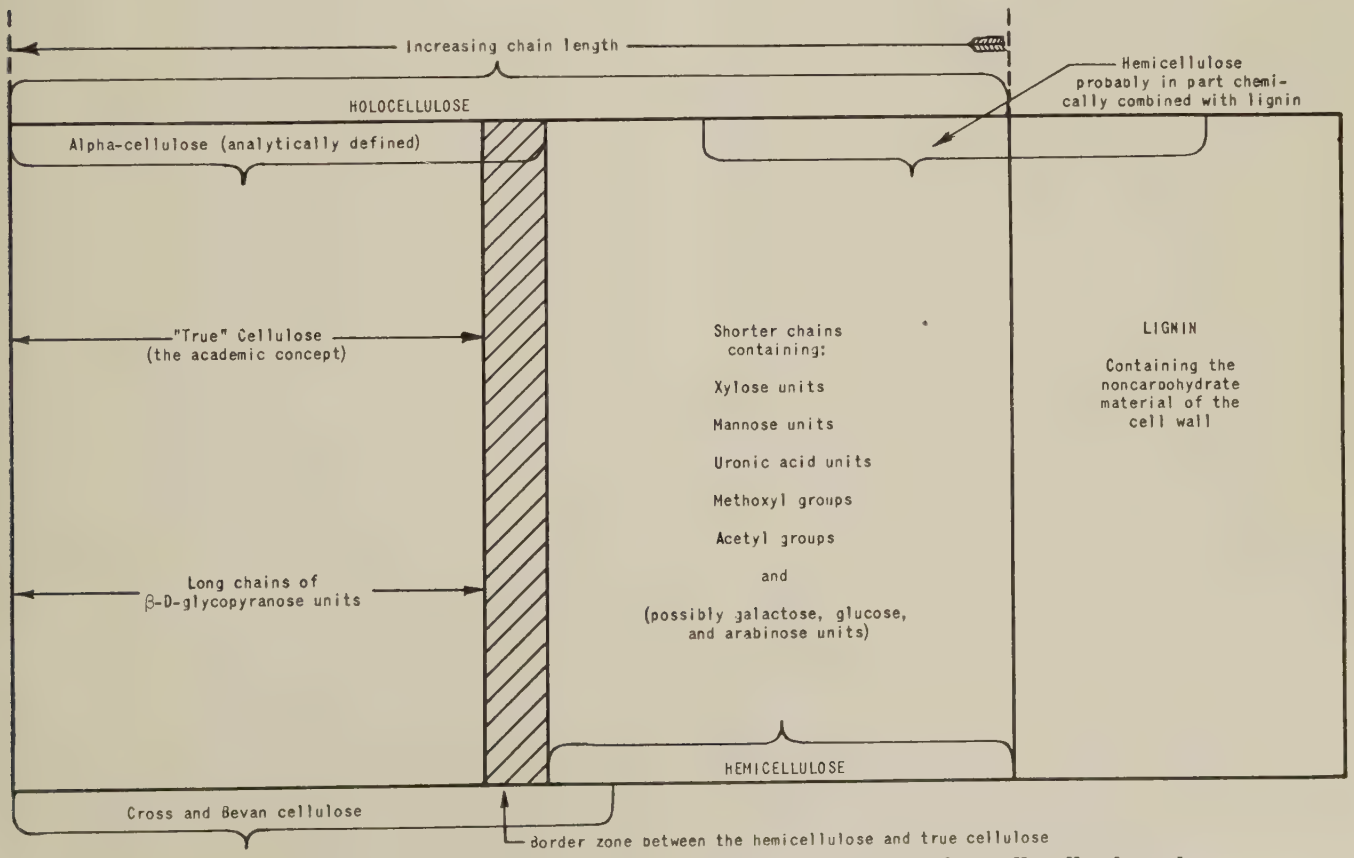

Fig. 1. Schematic diagram of the components of the extractive-free cell walls of wood

Table I. Wood Analyses

(Oven-Dry, Extractive-Free Basis)

Ocotea rubra (determa)	*Component, %*	*Quercus rubra (southern red oak)*
0.20	Ash	0.16
0.90	Acetyl	3.30
32.60	Lignin	25.20
53.20	Alpha-cellulose (not corrected for xylan, etc.)	45.70
13.90	Hemicelluloses	23.30
100.80	Total	97.66
18.85	Methoxyl in lignin	20.3

tions the alpha-cellulose content was high—ranging usually from 48 to 52% (on the extractive-free basis). This is in a range above that of many of our native hardwoods.

At this point Kawamura's statistical consideration of the composition of broadleaf trees (*5*) may be of interest. He used data collected by Nishida on 186 hardwoods grown in temperate climates. Kawamura's calculations indicated an average pentosan content of 20.8 ± 2.7% and an average lignin content of 22.1 ± 3.3% for nontropical species. His report also included cellulose figures (54.9 ± 3.5%), but furnished no alpha-cellulose data.

Within the past 10 years, a number of chemists have made significant contributions to the chemistry of tropical hardwoods—the following citations although incomplete, may be taken as typical. Goldsmid (*6*) published a monograph on the woods of tropical (French) Africa. Miura studied the chemical composition of Philippine woods (*7*) and those of British North Borneo (*8*). Hujinaga (*9*) analyzed several angiosperms of Micronesia. Belgian Congo woods were studied extensively by Castagne, Adriaens, and Istas (*10*) and by Lebacq and Istas (*11*). Mr. Istas has kindly supplied us with his more recent unpublished analytical data on hardwoods of the Congo (*12*).

Do these extensive analytical data reflect the same trends noted at the Institute? In other words, are the lignin contents in general higher and the pentosan (or xylan) contents lower than those found in hardwoods of temperate zones? And what of the cellulose contents? The answer presents difficulties because the analytical techniques were often so widely divergent from those used at the Institute and, more especially, because seldom has cognizance been taken of the methoxyl contents of the isolated lignins. Furthermore, few actual hemicellulose analyses have been recorded, and thus we have to content ourselves with over-all pentosan figures (uncorrected for uronic anhydride) and often not easily correlated with hemicelluloses (as we have pleased to define them). However, if we look over the vast tabulation of Istas' latest analytical data on woods from the Congo, entailing 67 wood samples (in which over 20 families are represented), we find 36 whose lignin content is far above the upper range given by Kawamura for woods of temperate zones. Similarly, 38 samples gave (uncorrected) pentosan values well below the lower values given by this same statistician. Istas' alpha-cellulose figures are much lower than those found at the Institute. This can probably be ascribed to divergent techniques used in the determination. Hence, these data cannot be compared with our own. This is also true for the cellulose analyses reported by other investigators.

Very recently, the problem of classifying tropical woods has been undertaken by Savard (*13*) of the Laboratoire du Centre Forestier Tropical. This laboratory analyzed several hundred tropical species for ash, extractives, cellulose, lignin, furfural-yielding components, etc., but (up to the present) found it impossible to correlate analytical data with other properties of the woods. Savard has attempted a statistical analysis of his data, for which the original paper must be consulted. For most of their woods the average lignin value was about 32%; however, for woods from Guadeloupe the average figure dropped to 27.6%. These two values are well above the average for hardwoods of the temperate zones. Whereas Savard gave no pentosan figures, he recorded the average value of 9.6% "furfural" for most of the tropical woods. This corresponds to about 16.4% pentosans. In the case of woods from Guadeloupe, the furfural value is 9.9% (≃ 16.9% pentosans). These averages are below those given by Kawamura for woods of temperate zones.

Woods from the Philippines and British North Borneo explored by Miura show in most cases the same trend. The pentosans are relatively low, lignin values are high, and the cellulose values cannot be compared with our own.

Such trends, of course, must be viewed cautiously and they certainly do not apply to all hardwoods grown in the tropics. The factors of site, soil type, rainfall, altitude, etc., would have to be considered.

Another difference observed at the Institute between the tropical woods and those of temperate climates is that of the potassium content of the wood ash. Whereas such woods as aspen, alder, paper birch, yellow poplar, maple, and southern red oak invariably give an ash rich in potassium, seven of the tropical woods examined were evidently low in potash. Spectral potassium lines were weak. This, however, is not a universal trend because in a few instances, we found evidence of a relatively high potash content, and the unpublished work of Istas shows evidence that only very few of the woods examined by him showed low potassium contents.

In closing let me say that the study of the extractives of the tropical woods is far more intriguing and challenging than are the data of summative analyses described above. The extractive content varied from 5 to 16% of the dry weight of the wood. The extraneous components characterize and "finger-print" the woods, but only in a few cases have they been studied.

Table II. Wood Analyses

(Oven-Dry, Extractive-Free Basis)

Ocotea rubra (determa)	*Component, %*	*Quercus rubra (southern red oak)*
0.2	Ash	0.16
0.9	Acetyl	3.30
32.6	Lignin	25.20
50.8	Alpha-cellulose (corrected for lignin, ash, xylan, uronic anhydride)	43.70
13.0	Total xylan	20.00
4.2	Total uronic anhydride	4.52
0.5	"CH_2" (calculated from methoxyl not in lignin)	0.60
102.2	Total	97.48

However, we have been able to confirm the frequently reported presence of *lapachol* (*14*) in *Tabebuia guayacan* and of *2-methylanthraquinone* (*15*) in teak.

One of the most interesting of all the tropical woods examined was *Ocotea rubra* which yielded well over 4% of a wax. This contains several components, only two of which have been separated chromatographically and purified to constant melting point. This type of purification, of course, does not insure chemical homogeneity. One of the components appears to be the lactone of a new trihydroxy acid, m. 89 to 90°C., and has the empirical formula, $C_{17}H_{30}O_4$. The other is an aliphatic acid, probably $C_{27}H_{55}CO_2H$ (closely related to montanic acid), m. 82.5 to 83.5°C. A more complete characterization of these components of *Ocotea rubra* is reserved for future publication.

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Fiber Measurements of Tropical Wood Fibers

IRVING H. ISENBERG

The possible utilization of tropical hardwoods as a fibrous raw material for pulp has been considered innumerable times during the first half of the twentieth century. Many investigators have reported fiber length measurements for the species examined (*1–19*). Some in this group have also measured the fiber diameter and a few have determined the proportion of various wood cell elements in the over-all volume. A cursory search of the literature revealed data collected as early as 1911 (*4a, 4b*) and a more intensive examination would perhaps disclose earlier information on fiber dimensions of tropical hardwoods.

In accord with our desire to learn as much as possible concerning a given species with intent toward exploitation, dimensional data have been collected on 12 species of tropical American hardwoods, as well as for teak, a well-known species from Burma.

The species on which measurements were made are listed in Table I. They were those woods whose proximate chemical composition had been determined at The Institute of Paper Chemistry (*20*). These woods, in turn, had been selected from a much greater number of tropical hardwoods tested physically at the Yale School of Forestry (*21*). It must be emphasized that these species were studied because the physical and chemical data were at hand and not because they were deemed suitable for pulping.

Small sticks were selected at random from several points in sample blocks sent by the workers at Yale University. These blocks were obtained from butt logs of one or more trees. The sticks were macerated by the acetic acid-sodium chlorite method (*22*).

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The pulps were stained with Congo red and sufficient fibers were aligned on microscope slides to give approximately 200 unbroken fibers and 50 vessel segments, which were measured for length and width by means of projection at 75 diameters (*23*). Wall thickness in relation to fiber diameter was determined on ten fibers at higher magnification. The ratio is expressed as the percentage of radius.

The measurements obtained on the fibers and vessel segments are recorded in Tables II and III. In certain species the material from different logs had been kept separate. These data are given in Table II whereas, in Table III, the values are grouped for individual species.

The fiber lengths of several of the more commonly pulped hardwood species of Europe and the United States are tabulated in Table IV. Values for the European woods are taken from Mühlsteph (*24*) and those for the American species from Isenberg (*25*).

Comparison of the values listed in Tables III and IV shows that the fiber lengths of the tropical hardwoods

Table I. Species Names

Technical	*Common*
Cordia alliodora	Laurel blanco
Couratari pulchra	Tanary
Dicorynia paraensis	Angelique
Eschweilera sagotiana	Kakeralli
Hymenaea courbaril	Courbaril
Licaria cayennensis	Kaneelhart
Manilkara bidentata	Bulletwood
Ocotea rodiaei	Greenheart
Ocotea rubra	Determa
Pseudosamanea guachapele	Frijolillo
Swietenia macrophylla	Mahogany
Tabebuia guayacan	Guayacan
Tectona grandis	Teak

Table II. Dimensions of Fibers and Vessel Segments

Species	Yale no.	Fibers: Length, mm. Range	Fibers: Length, mm. Av.	Fibers: Width, mu Range	Fibers: Width, mu Av.	Fibers: Wall thickness Mu	Fibers: Wall thickness % radius	Vessel segments: Length, mm. Range	Vessel segments: Length, mm. Av.	Vessel segments: Width, mm. Range	Vessel segments: Width, mm. Av.
Cordia alliodora	85	0.3–2.4	1.33	10–60	26	3.4	26	0.14–0.38	0.27	0.07–0.36	0.22
Cordia alliodora	86	0.7–2.2	1.34	10–50	28	2.8	20	0.17–0.51	0.26	0.14–0.30	0.22
Cordia alliodora	320	0.6–1.9	1.34	10–40	27	4.2	31	0.1 –0.4	0.25	0.1 –0.3	0.22
Couratari pulchra	122, 214, 379	0.6–2.3	1.49	10–40	22	3.3	30	0.32–0.95	0.62	0.05–0.41	0.28
Dicorynia paraensis	245, 246	0.6–2.3	1.39	10–40	23	4.5	39	0.28–0.58	0.45	0.08–0.49	0.30
Eschweilera sagotiana	213, 215	0.8–2.4	1.59	10–30	19	7.3	77	0.21–0.80	0.54	0.10–0.59	0.28
Hymenaea courbaril	103	0.4–1.6	1.03	10–30	20	4.8	48	0.14–0.50	0.29	0.13–0.40	0.26
Hymenaea courbaril	104	0.6–1.9	1.21	10–30	20	4.2	42	0.22–0.45	0.34	0.10–0.34	0.21
Licaria cayennensis	243	0.9–2.3	1.54	10–40	21	7.7	73	0.5 –1.6	0.85	0.10–0.33	0.21
Manilkara bidentata	161	0.6–2.0	1.44	10–40	22	8.5	77	0.5 –1.0	0.71	0.03–0.22	0.15
Manilkara bidentata	162	0.4–1.7	1.24	10–40	22	9.7	88	0.4 –0.9	0.64	0.04–0.18	0.13
Manilkara bidentata	163	0.6–1.5	1.10	10–40	21	8.8	84	0.5 –1.0	0.69	0.04–0.32	0.14
Manilkara bidentata	242	0.9–2.0	1.54	10–30	23	9.8	85	0.10–1.11	0.75	0.04–0.19	0.13
Ocotea rodiaei	...	0.4–1.6	1.04	10–40	26	7.5	58	0.35–0.88	0.59	0.13–0.34	0.25
Ocotea rubra	241	0.6–2.6	1.78	10–60	35	9.1	52	0.4 –1.1	0.77	0.09–0.56	0.28
Ocotea rubra	249	1.0–2.8	2.00	20–50	33	10.2	62	0.5 –1.1	0.81	0.1 –0.4	0.28
Pseudosamanea guachapele	79	0.4–1.4	0.84	10–40	20	3.6	36	0.10–0.41	0.26	0.08–0.36	0.24
Pseudosamanea guachapele	80	0.3–1.2	0.92	20–40	24	4.0	33	0.10–0.44	0.32	0.02–0.37	0.24
Pseudosamanea guachapele	81	0.5–1.5	1.00	10–40	21	3.8	36	0.18–0.50	0.29	0.10–0.50	0.25
Swietenia macrophylla	462	0.7–2.3	1.42	10–60	28	3.3	24	0.25–0.65	0.49	0.07–0.40	0.24
Tabebuia guayacan	82	0.5–1.5	0.99	10–30	15	5.3	71	0.19–0.30	0.24	0.10–0.23	0.16
Tabebuia guayacan	83	0.5–1.5	0.97	10–30	20	5.1	51	0.16–0.35	0.26	0.06–0.20	0.14
Tabebuia guayacan	84	0.4–1.3	0.90	10–30	12	4.7	78	0.14–0.31	0.24	0.04–0.27	0.17
Tectona grandis	461	0.6–2.0	1.29	20–50	30	6.0	40	0.1 –0.4	0.28	0.13–0.52	0.30

determined in the present study have a distribution similar to the lengths reported for the commonly pulped European and American hardwoods. In other words the lengths run the gamut from less than 1 mm. to approximately 2 mm.

A few of the species have been measured previously. Teak (*Tectona grandis*) from Burma (*3b*) had a range in fiber length from 0.7 to 1.4 mm. and in diameter from 30 to 37 mu. Teak grown in plantations in Trinidad (*1q*) gave an average fiber length of 0.9 mm., with a range from 0.4 to 1.6 mm. and an average diameter of 27 mu, with a range from 14 to 44 mu. It has been demonstrated that the fibers of teak are considerably longer in the last formed late wood of the growth ring than in the first formed early wood (*13*). Greenheart (*Ocotea rodiaei*) (*1l*) had an average length of 1.2 mm., with a range of 0.8 to 2.0 mm. and an average diameter of 15 mu, with a range of 5 to 25 mu. Mahogany (*Swietenia mahagoni*) (*17*) had an average fiber length of 1.0 mm., with a range of 0.7 to 1.3 mm.

The foregoing values are similar to those found presently for these species. Considering the fact that the location in the tree, the maturity of the wood, the location in the growth ring, the rate of growth and, possibly, other factors can affect fiber dimensions, slight differences are not significant. Another point which should be emphasized is the failure to collect sufficient data for the calculation of averages. In far too many instances no mention is made of the number of measurements, maximum or minimum values, or standard deviation. It is our practice to measure at least 200 fibers and, if practicable, many more.

In the reports of scientists of various nationalities, average fiber lengths for tropical hardwoods ranging from 0.3 to 2.80 mm. have been determined (*1–19*). A creditable percentage of these is more than 2 mm. long. In addition, one could mention dicotyledonous genera such as *Drimys*, *Trochodendron*, and *Zygogynum* (hardwoods without vessels), whose average fiber lengths exceed 4 mm.

The average fiber diameter of the species measured ranged from 16 to 34 mu, with all but a few being between 20 and 30 mu. This is the range of measurements typical of hardwood fibers, although a few narrower ones and several wider ones, notably *Musanga smithii* which is given as 75 mu by some authorities (*4d*), have been reported.

The average thickness of the fiber wall was 3.3 to 9.6 mu. It is important at times to consider the thickness of the wall in relation to the diameter. If wall thickness is expressed as a ratio of fiber radius values, from $^1/_4$ to $^6/_7$ were found. Once again it is found that the results are similar to those given for other tropical and temperate hardwood species. There appears to be

Table III. Grouped Dimensions of Fibers and Vessel Segments

Species	Fibers: Length, mm. Range	Fibers: Length, mm. Av.	Fibers: Width, mu Range	Fibers: Width, mu Av.	Fibers: Wall thickness Mu	Fibers: Wall thickness % radius	Vessel segments: Length, mm. Range	Vessel segments: Length, mm. Av.	Vessel segments: Width, mm. Range	Vessel segments: Width, mm. Av.
Cordia alliodora	0.3–2.4	1.34	10–60	27	3.5	26	0.10–0.51	0.26	0.07–0.36	0.22
Couratari pulchra	0.6–2.3	1.49	10–40	22	3.3	30	0.32–0.95	0.62	0.05–0.41	0.28
Dicorynia paraensis	0.6–2.3	1.39	10–40	23	4.5	39	0.28–0.58	0.45	0.08–0.49	0.30
Eschweilera sagotiana	0.8–2.4	1.59	10–30	19	7.3	77	0.21–0.80	0.54	0.10–0.59	0.28
Hymenaea courbaril	0.4–1.9	1.12	10–30	20	4.5	45	0.14–0.50	0.32	0.10–0.40	0.24
Licaria cayennensis	0.9–2.3	1.54	10–40	21	7.7	73	0.5 –1.6	0.85	0.10–0.33	0.21
Manilkara bidentata	0.4–2.0	1.33	10–40	22	9.2	84	0.10–1.11	0.70	0.03–0.32	0.14
Ocotea rodiaei	0.4–1.6	1.04	10–40	26	7.5	58	0.35–0.88	0.59	0.13–0.34	0.25
Ocotea rubra	0.6–2.8	1.89	10–60	34	9.6	56	0.4 –1.1	0.79	0.09–0.56	0.28
Pseudosamanea guachapele	0.3–1.5	0.92	10–40	22	3.8	35	0.10–0.50	0.29	0.02–0.50	0.24
Swietenia macrophylla	0.7–2.3	1.42	10–60	28	3.3	24	0.25–0.65	0.49	0.07–0.40	0.24
Tabebuia guayacan	0.4–1.5	0.95	10–30	16	5.0	63	0.14–0.35	0.25	0.04–0.27	0.16
Tectona grandis	0.6–2.0	1.29	20–50	30	6.0	40	0.1 –0.4	0.28	0.13–0.52	0.30

Table IV. Fiber Lengths in Mm. of Commonly Pulped Hardwood Species

Acer rubrum	Red maple	0.74
Aesculus octandra	Yellow buckeye	0.91
Betula papyrifera	Paper birch	1.10
Betula verrucosa	European birch	1.25
Castanea dentata	American chestnut	0.98
Fagus grandifolia	American beech	1.16
Fagus silvatica	European beech	1.03
Liquidambar styraciflua	Sweetgum	1.70
Liriodendron tulipifera	Yellow poplar	1.88
Nyssa sylvatica	Black tupelo	1.76
Populus balsamifera	Balsam poplar	1.19
Populus grandidentata	Bigtooth aspen	1.11
Populus tremula	European aspen	0.95
Populus tremuloides	Trembling aspen	1.04
Salix nigra	Black willow	1.09

no correlation between wall thickness and fiber diameter.

The proportion of the total volume occupied by fibers, vessels, and wood parenchyma or rays was not determined on these samples. Teak has been reported (*3a*) as containing 66% fibers by volume. The limited data available on tropical woods give values from 28 to 79% (*3a*, *5b*). Huber and his associates also gave proportions of other cell elements as well as of fibers.

The lengths and diameters determined for the vessel segments of the tropical hardwoods are reported in Tables II and III. These values are similar to those given in the literature for other hardwoods (*17*, *26*, *27*).

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The Influence of Chipping on the Properties of Paraná Pine Sulphite Pulp

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The loss of the mechanical strength during the drying of sulphite pulp made from Paraná pine and, very likely, from other woods also is caused by mechanical damage which takes place during the chipping. This mechanical damage of the wood structure is the reason for the chemical deterioration of the cellulose fiber during the cooking with sulphite liquor with following easy breakage of the same before and during the mechanical treatment. The pulp made of wood chipped under very mild mechanical conditions has longer fibers, less fines, higher viscosity, higher strength values, and does not suffer loss of strength during the drying when compared with pulp produced of mill-chipped wood. How far this physical superiority is related to chemical values must be further investigated. The higher content of long fibers may be the reason why pulp from hand-chipped wood requires more time for screening. The better quality of fibers from hand-chipped wood is very likely the reason for the longer beating time needed. The improvement of the impregnation period by long soaking, steaming, evacuation, and high initial pressure has beneficial influence on machine-chipped wood under normal cooking conditions. The best impregnated machine-chipped wood never gives as strong pulp as hand-chipped wood. The hand-chipped wood gives unbeaten and beaten pulp with much more long fibers and less fines than machine-chipped wood. Low speed chipping gives pulp with still less long fibers and more fines than machine-chipped wood. Practical methods should be found to chip wood to prevent mechanical damage to fibers with

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resultant chemical deterioration during the chemical treatment. The stability of mechanical strength during the drying may be used as a measure for such improvement. The influence of the chipping on the quality of the sulphite pulp must be considered as fundamental and all pulp investigation and research results without standardization or improvement of the chipping condition are uncertain.

It is well known that drying a chemical pulp influences its physical properties. Lyne and Gallay (*1*) have recently shown to what extent the strength of a sulphite pulp is lowered as the degree of drying increases. They found a nearly linear relationship between the percentage loss in burst, tensile, and folding strengths and the dryness of the pulp, the loss being as much as 80% of the original strength in the case of a bleached sulphite pulp when the moisture content is decreased to below 10%.

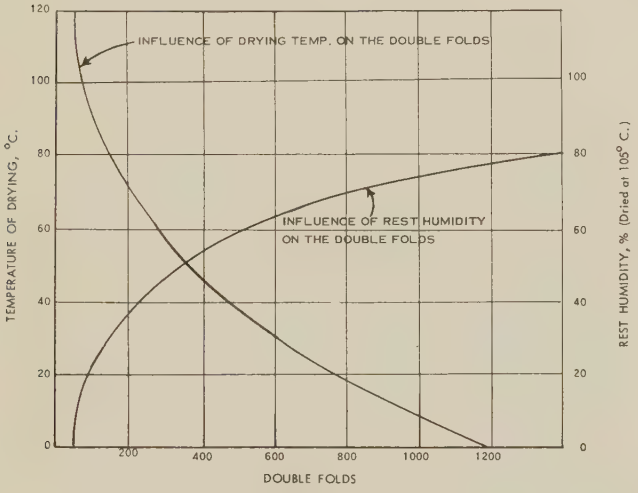

Fig. 1

On drying Paraná pine sulphite pulp, either bleached or unbleached, similar losses in pulp strength are observed; this is especially true with folding strength. The change in tensile and fold of Paraná pine sulphite pulp when dried at different temperatures to a moisture content of 10 to 12% is shown in Fig. 1 and when dried to different moisture contents at 105°C., in Fig. 2.

Various reasons are advanced to show why chemical pulps undergo these changes. This is generally associated with some kind of irreversible change in the swelling properties or to irreversible hardening or "hornification" because of the drying, which is the cause of these changes in pulp properties.

Such a change should not be attributed to the influence of the high temperature alone, because it occurs just as well on air drying at room temperatures, although it proceeds at a faster rate at the higher drying temperatures.

The author has already shown (*2*) that Paraná pine sulphite pulp does not exhibit the high strength that might be expected from an average fiber length of 4 mm., said to be the highest among the conifers. Even lower strengths resulting from drying would still further devaluate the pulp, so an experimental program has been undertaken to determine how this devaluation might be prevented or kept at a minimum. Three factors have been studied—namely, the quality of the wood itself, the influence of cooking conditions, and the influence of bleaching conditions.

The wood used, which comes from the virgin forests of Paraná, Brazil, is characterized by a lack of uniformity. The sapwood resembles sprucewood; then there is an irregular reddish ring which surrounds the brown heartwood. The fiber length often reaches 7 to 9 mm. in length. The specific gravity of sap- and heartwood runs between 0.45 to 0.56 and 0.48 to 0.60, respectively. The chemical composition of the sap- and heartwood is given in Table I.

Table I. Chemical Components of Paraná Pinewood

	Sapwood	*Heartwood*
Solubility		
Water	1.2	0.8
Ether	1.8	0.4
Alcohol-benzene	2.6	2.1
1% NaOH	10.2	11.6
Ash	0.4	1.4
Lignin	29.1	31.7
Pentosan	4.8	4.2
C&B cellulose	65.5	62.5

TAPPI Standard Methods.

Wood was converted to chips for cooking by one of three ways: (1) machine chipped on a ten-knife Carthage chipper, 96 inch diameter; (2) machine chipped on a four-knife Kamyr chipper, 110 inch diameter; (3) handmade chips were prepared by sawing the wood transversely into disks of $^1/_2$ inch thickness, then splitting with a hand knife into chips of approximately commercial size.

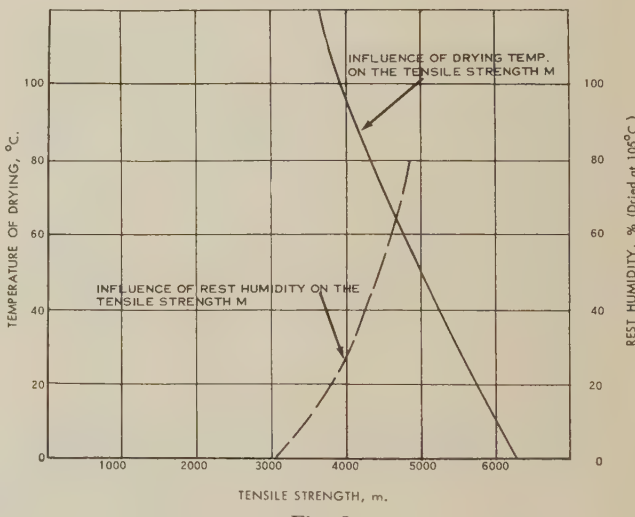

Fig. 2

Pulping experiments were carried out in part by suspending chips in perforated stainless steel baskets in 135-cu. m. digesters heated by direct steam with forced circulation and in part in an experimental digester of 180-l. capacity equipped for liquor circulation and indirect heating. The pulps were screened on an experimental flat screen and beaten in a Lampén mill or standard Valley beater. Sheets were made on the standard Williams sheet apparatus. Strength tests were carried out at 65% R. H. and 68°F. (20°C.). In conformity with the work of Anderson (*3*), the pulp made from hand chips always showed better physical properties than did pulp from machine chips.

A comparison of pulps made in the baskets in the commercial digester with those made in the experimental digester is given in Table II. In the commercial digester the basket containing the hand chips was suspended adjacent to and at the same level as the basket containing the machine chips.

Similar experiments were carried out in the smaller experimental digesters with very little difference in results. Again, the hand-chipped wood gave better pulp than did the machine-chipped wood, as will be seen from Table III.

Table II. Comparison of Pulp Quality as the Result of Hand versus Machine Chipping; Cooks in Baskets Suspended in Commercial Digesters

Cook	11	11	13	13	27	27
Chipping method	Hand	Machine	Hand	Machine	Hand	Machine
Roe number	2.4	1.4	2.6	2.1	2.6	1.4
Viscosity, cp.	16.4	13.2	43.5	36.1	37.5	36.5
G.E. brightness, %	49	55	57	60	..	..
Beating time, min.	54	42	64	48	60	45
Schopper-Riegler	40	40	40	41	45	45
Tensile strength, m.	6142	4136	6733	5571	8578	6966
Double folds	4673	516	5652	2016	4470	1466
Burst, kg./sq. cm.	7.3	2.5	4.8	3.7	5.5	4.3
Tear (Elmendorf), 100g.	52.6	26.3	46.5	32.6	39.1	32.1

It is well known that wood which has been mechanically pressed or stored in hot water before chipping gives pulp of inferior strength. This has been shown by Hägglund (*4*), Bildt (*5*), and Groegaard (*6*). Somewhat the same phenomenon was described by Haywood

Table III. Comparison of Pulp Quality as the Result of Hand versus Machine Chipping; Cooks Made in the Experimental Digester

Cook		86	82
Chipping method		Hand	Mill
Roe number		5.0	5.5
G.E. brightness, %		45	43
	S.-R.		
Beating time, min.	55	54	56
Tensile strength, m.	25	8709	5399
	35	9216	6166
	55	8450	6925
Double folds	25	2222	630
	35	3319	815
	55	4123	1244
Burst, kg./sq. cm.	25	6.39	3.32
	35	6.49	3.53
	55	6.10	3.90
Tear (Elmendorf), 100g.	25	44.2	36.9
	35	40.3	31.2
	55	37.5	26.1

(*7*) with compressed chips. This is explained by the assumption that, as the result of strong mechanical action, the material protecting the main cellulose layers is damaged so that the pulping chemicals degrade the cellulose before the main part of the lignin is removed.

In order to determine whether the same assumption can be made to explain the poorer quality of machine-made chips or whether penetration time is slowed up as the result of a physical change during chipping, the following experiments were carried out.

1. Differences in the specific gravities of hand- and machine-made chips.
2. The influence of chip size and the effect of the knife on the chip surface on pulp quality.
3. The amount of air liberated when the chips were heated in water.
4. The effect of high pressure on handmade chips on pulp quality.
5. The effect of chipping wood at slow speed on pulp quality.
6. The effect of a better impregnation through steaming and evacuation on pulp quality for both hand- and machine-made chips.
7. Microscopic studies of these pulps.

SPECIFIC GRAVITY STUDIES

Two sets each of white sapwood and reddish heartwood chips were isolated from both hand- and machine-made chips; 100 specific gravity determinations were made for each sample using the mercury method in the Amsler apparatus. The average values for the sapwood hand chips are 0.52 and 0.50 and for the sapwood machine chips, 0.56 and 0.52. For the heartwood the analogous values are 0.59 and 0.59 for both hand chips and

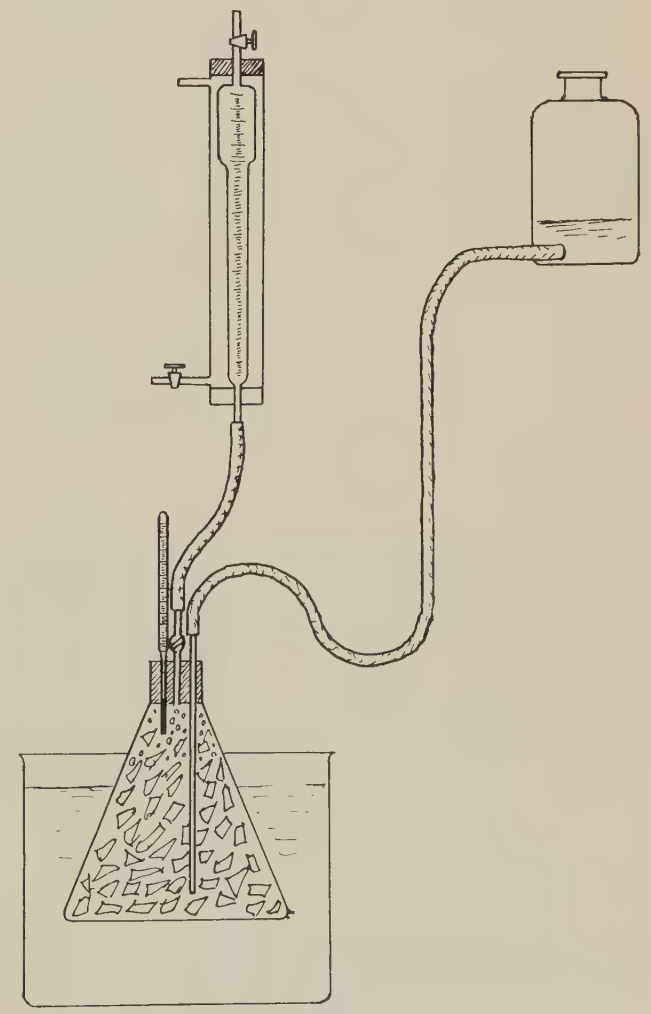

Fig. 3

machine chips. Thus, the method of chipping has no effect on the density of the heartwood chips; machine-chipped sapwood has a 6% higher specific gravity than does hand-chipped sapwood, possibly because of compression during the chipping.

The determinations of the specific gravity were carried out several days after the chipping, so that any reversion in volume could take place in the meantime.

LIBERATION OF AIR ON HEATING IN WATER

Wood from the same log was hand and machine chipped, stored in an Erlenmeyer flask for a certain time under cold water, and stirred a few times to drive out the surface air. The flask was then connected with a volumetric buret and water inlet pipe and funnel (see Fig. 3). After filling the whole system with water, the Erlenmeyer flask was slowly heated in a water bath. The temperature, time, and volume of air accumulated in the buret were registered after equalizing the water level in the funnel of the buret. The volume of free air in the chips is shown in Table IV.

Table IV. Relative Volumes of Air Given Off by Hand- and Machine-Chipped Samples of Parana Pine on Heating in Water

Time, min.	*Temperature, °C.*	*Machine chips, air volume in 100 g. b.d. wood, cc.*	*Temperature, °C.*	*Hand chips, air volume in 100 g. b.d. wood, cc.*
10	33	0.46	33	0.75
20	38	1.84	38	2.62
30	42	3.55	43	6.98
40	48	6.10	48	10.43
83	63	20.03	62	27.80
100	66	24.4	70	39.5
122	74	34.4	74	50.0
154	86	61.0	70	52.0
172	88	64.3	78	53.2
187	90	70.0	83	64.8
205	90	71.2	89	78.5
223	89	70.8	89	81.8
230	89	71.2	89	82.5
Wood moisture at the start:		18%		14%

A control test gave the following figures:

Time, min.	*Temperature, °C.*	*Machine chips, cc. air/100 g. b.d. wood*	*Hand chips, cc. air/100 g. b.d. wood*
150	78	50.2	61.2
Chips humidity at the start		20.5%	18.7%

The hand-chipped wood gave about 20% more air than the machine-chipped wood. These relatively simple experiments indicate clearly that machine chipping has a definite influence on the structure of the chips; the results are in agreement with the higher average density of the machine-made chips. The easier air removal from handmade chips is very likely related to the fact that normal means for improving the penetration (steaming, evacuation) have no effect on the pulp quality from handmade chips, as will be seen later.

INFLUENCE OF CHIP SIZE AND KNIFE EFFECT

To find out whether some kind of surface plugging of the chips occurs as the result of machine chipping, the edges of the machine-made chips were cut off with a saw and compared with the original machine-made chips. Table V gives the results.

Practically no difference was observed in the quantity of liberated air. This indicates that some kind of surface plugging is not the reason for the different behavior of the machine-chipped and hand-chipped wood during the cooking.

The poorer quality of pulp from machine-chipped wood is very likely related to some kind of mechanical action which takes place within the chips.

Table V. Comparison of Air Evolution from Machine-Made Chips with and Without Edge Removal

Time, min.	*Temperature, °C.*	*Original mill chips, air volume in 100 g. b.d. wood, cc.*	*Temperature, °C.*	*Mill chipped and edges removed, air volume in 100 g. b.d. wood, cc.*
5	28	2.46	29	0.0
10	32	2.87	32	1.62
25	43	3.69	44	2.84
40	52	8.22	52	5.28
55	59	16.44	60	14.23
70	66	25.48	67	24.79
100	73	37.81	74	38.21
110	74	41.90	75	42.27
120	74	42.74	76	43.08
Wood moisture at the start:		18.9%		18%

Handmade chips with different thickness were cooked together in perforated baskets in the mill digester. The effect of chip size (thickness, length, and width being the same) is shown in Table VI.

Table VI. The Effect of Variations in Thickness of the Chips Made by Hand Chipping

Size of the chips		Thin	Thick
Length, cm.		2.5	2.5
Width, cm.		3.0	3.0
Thickness, cm.		0.25	0.50
Roe number		2.8	4.2
G.E. brightness, %		48	46
Rejects, %		0.6	1.5
Screening speed, g./min.		5.6	7.6
Fiber fractionation			
14-mesh wire, %		76.26	80.25
28-mesh wire, %		88.36	92.57
48-mesh wire, %		92.86	96.23
100-mesh wire, %		95.26	98.59
Fines, %		4.74	1.44
	S.-R.		
Tensile strength, m.	32	9300	9250
	39	8407	8040
	49	8000	7905
Double folds	32	2296	1976
	39	2932	2391
	49	3303	2697
Burst, kg./sq. cm./100 g.	32	6.3	7.0
	39	5.3	6.3
	49	5.0	6.0
Tear (Elmendorf), 100 g.	32	41.8	43.9
	39	40.1	43.6
	49	39.2	41.5
Beating time, min.	32	40	38
	39	50	46
	49	62	56

The thinner chips cook a little faster and the pulps have less fines; otherwise, there is not any significant difference in pulp quality.

To check once more the possible influence of the chipper knives on the chip edges, the edges were cut off with a saw and razor blade, alternatively. The samples thus prepared were cooked, together with original machine-made chips, in the mill digester. The characteristics of the pulps are given in Table VII.

Again, the difference in the pulp quality is probably not significant, and the influence of the surface plugging would not seem to be important. Therefore, mill chipping must influence the structure of the whole chip.

THE EFFECT OF PRESSURE ON HANDMADE CHIPS

To ascertain to what extent the pulp quality is changed when handmade chips were compressed before cooking, one sample of handmade chips was pressed in a laboratory hydraulic press for 20 minutes in air; a second sample was pressed in water. These two samples were cooked, together with a control cook of unpressed handmade chips, in the mill digester in perforated baskets. The results are given in Table VIII.

Table VII. The Effect of Chip Edge Removal on the Quality of Paraná Pine Sulphite Pulps

Cooking conditions: Paraná pine sulphite pulps
Acid composition: Total SO_2, 4.32%
Combined SO_2, 1.09% as CaO

			Machine-chipped wood	
	S.-R.	*Original*	*Edges cut off with a saw*	*Edges cut off with razor blade*
Screenings, %		4.16	2.92	3.49
Screening speed, g./min.		10.15	14.35	13.81
Roe number		3.0	3.0	2.7
G.E. brightness, %		43	45	48
Fiber fractionation				
14-mesh wire, %		61.93	68.73	60.43
28-mesh wire, %		80.57	82.64	76.28
48-mesh wire, %		88.90	89.93	89.40
100-mesh wire, %		92.23	93.21	94.35
Fines, %		7.77	6.79	5.65
Tensile strength, m.	30	5230	5137	4600
	40	6250	5740	5218
	51	7172	6680	5612
Double folds	30	251	794	538
	40	487	890	619
	51	1010	1299	756
Burst, kg./sq. cm./100 g.	30	3.8	3.8	3.0
	40	3.6	3.9	3.1
	51	4.2	4.3	3.3
Tear (Elmendorf), 100 g.	30	32.73	32.15	29.27
	40	24.42	26.50	27.90
	51	23.84	22.59	21.77
Beating time in Valley Standard Beater, min.	30	24	30	30
	40	34	43	40
	50	44	53	53

Table VIII. Effect of Compression of Handmade Chips of Paraná Pine on the Physical Properties of Their Pulps

		Hand chipped				
	S.-R.	*Compressed air*	*S.-R.*	*Compressed under water*	*S.-R.*	*Original chips*
Roe number		3.3		3.6		3.6
Tensile strength, m.	31	5866	32	6000	32	6807
	41	6466	39	7233	42	7653
	52	6893	49	7680	52	7961
Double folds	31	1066	32	1258	32	2530
	41	1870	39	1668	42	2923
	52	2164	49	1852	52	3424
Tear (Elmendorf), 100 g.	31	36.8	32	38.7	32	41.3
	41	31.8	39	38.6	42	36.9
	52	29.5	49	36.8	52	38.7
Burst, kg./sq. cm., 100 g.	31	4.0	32	4.1	32	5.8
	41	4.1	39	4.3	42	6.0
	52	4.2	49	4.5	52	6.2
Beating time, min.	32	18	31	21	32	35
	41	23	39	27	42	43
	52	29	49	34	52	51

Significant differences will be seen in all the physical characteristics but especially in folding strength between the pulps from the handmade chips with and without compression. In this way the pressure-treated chips resemble machine-made chips. Further, the beating time of the pulp from the compressed chips is much shorter than that of the original handmade chips.

THE EFFECT OF WOOD CHIPPING AT SLOW SPEED

During the chipping of wood in the mill chipper, there seem to be two main mechanical forces which may influence the fiber quality: (1) action of the cutting knife which is successively dislocating the fiber layers, and (2) the blow action of the knife support which hits the cut wood slice and breaks it to pieces.

To eliminate one of these forces, the wood was cut with a slow-moving knife mounted on the upper plate of a hydraulic pulp bale press. On cooking these chips, machine-chipped and handmade chips (all from the same wood), the expected improvement was not found but deterioration of the yield and of the chemical and mechanical qualities of the pulp made from these chips resulted.

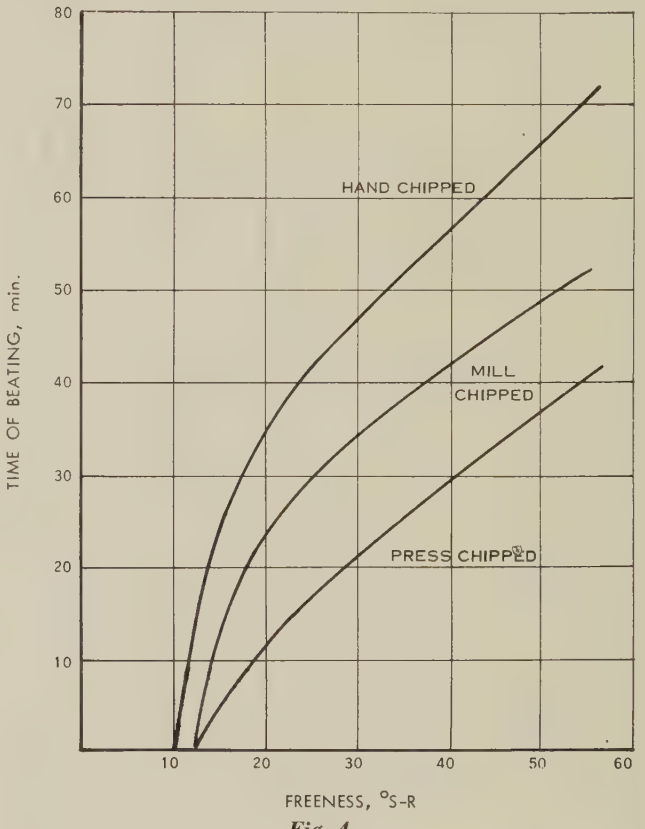

Fig. 4

The three samples were cooked with an acid having a total SO_2 of 5.38% and a CaO content of 0.70%, with a total cooking time of 10 hours and a maximum temperature of 145°C.

Table IX gives the chemical composition and yield of pulps made from these wood samples.

The hand-chipped wood is superior in all properties. The action of the acid is slower but apparently less harmful to the fibers.

Figure 4 shows graphically the rate of beating of the pulps described in Table IX. It is interesting to observe the regular decrease of the beating speed with the increase of fiber deterioration as a result of chipping.

Figure 5 shows the classification of the fibers before and during the beating of the same pulps. Figure 6 shows the increase of fines in these three pulps during the beating operation.

The mechanical damage resulting from chipping causes an increase in short fibers and fines, the pulp from the hand-chipped wood being the best, that from machine-chipped is medium and press-chipped the worst one in this regard. From the practical standpoint the pulp

Table IX. Chemical Composition and Pulp Yield from Wood Samples Chipped by Hand, in the Chipper, and Cut in the Press

Chipped by	*Hand*	*Mill*	*Press*
Yield, %	52.05	49.74	47.80
Screenings, %	2.78	0.85	1.91
Roe number	2.6	1.4	2.0
Viscosity, cp.	37.5	36.5	28.9
Alpha-cellulose, %	90.4	89.5	88.1
Alpha-cellulose (cor. for ash and lignin), %	90.0	89.0	87.4
Pentosans, %	0.65	0.55	0.53
Lignin, %	2.47	0.92	1.56

TAPPI Standard methods used.

yield in the mill will also depend on the quality of chipping, since the large amount of fines is lost in the white water.

The strength tests of the three pulps are given in Table X.

Table X. Physical Tests of Pulps Prepared by Different Methods of Chipping

	S.-R.	*Hand chipped*	*Mill chipped*	*Press chipped*
Double folds	12	1	8	3
	22	3016	1005	233
	33	3728	1239	371
	45	4470	1466	472
	56	5227	1557	885
Tensile strength, m.	12	1335	2135	1435
	22	7512	5857	5100
	33	8000	6333	5891
	45	8578	6966	6444
	56	8815	7038	6611
Burst, kg./sq. cm., 100 g.	12	0.5	0.9	0.5
	22	4.8	3.5	2.4
	33	5.1	3.9	2.8
	45	5.5	4.3	3.4
	56	6.0	4.1	3.3
Tear (Elmendorf), 100 g./sq. m.	12	83.8	65.2	44.1
	22	45.0	37.7	32.4
	33	42.0	35.0	29.2
	45	39.1	32.1	25.3
	56	36.5	28.5	20.0

Here, again, the superiority of hand chipping can be clearly seen; also, the difference in folding endurance is outstanding, indicating less damaged flexible fibers.

THE EFFECT OF BETTER IMPREGNATION THROUGH STEAMING AND EVACUATION

To verify the influence of the improved penetration into the handmade chips, they were cooked in the experimental digester under the following conditions:

SAMPLE I:

Cooking acid: total SO_2, 4.29%; CaO, 0.95%
Cooking conditions: no steaming or other preliminary treatment
3.5 hr. to 110°C.
1 hr. at 110°C.
3 hr. to 145°C.
5.5 hr. at 145°C.
Chips dimension, 2 by 3 cm.; thickness, 0.3–0.4 cm.; humidity of wood chips, 25%
Maximum digester pressure, 75 lb.

SAMPLE II:

Cooking conditions, size, and humidity of the chips and acid composition were practically the same but, before the cook, the chips in the digester were steamed without pressure, the digester was closed, well evacuated, filled with the acid, and the maximum pressure was held at 90 lb. The results are given in Table XI.

There is probably no significant difference in the pulp strength of I (cook 86) and II (cook 88), considering that cook 88 has a lower Roe number as a result of the

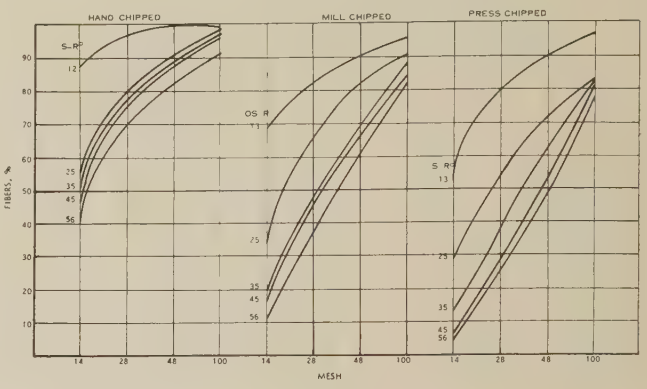

Fig. 5

higher cooking pressure. The strength values correspond well with the strength values obtained by cooking in baskets in the mill digester. There is no increase in the strength value because of the assumed better penetration or impregnation by the cooking liquor for

Table XI. Effect of Impregnation of Handmade Chips on Quality of Pulp

Cook		*86*	*88*
	S.-R.		
Sample		I, normal cooking	II, steamed before cooking
Yield, %		48	46.7
Screenings, %		2.3	0.95
G.E. brightness, %		45	46
Roe number		5.0	3.8
Valley beating time, min.	25	8709	7950
	35	9216	8300
	55	8450	8396
Double folds	25	2222	2442
	35	3319	2812
	55	4123	3631
Burst, kg./sq. cm., 100 g.	25	6.39	6.16
	35	6.49	6.07
	55	6.10	5.83
Elmendorf tear, 100 g.	25	44.2	31.9
	35	40.3	27.6
	55	37.5	20.0

hand-chipped wood. This is in sharp contrast to the fact that improved impregnation gives stronger pulps in mill operations. Paraná pine, chipped in the mill chipper and cooked experimentally, gives pulps having improved folding endurance, as can be seen in Table XII. In this cooking series, the machine-made chips, before cooking, were soaked overnight in the cooking acid, long cooked, steamed, evacuated, and cooked with higher pressure—even artificial pressure was appplied before the temperature rise.

In general it can be seen that the composition of the acid strength used does not have an outstanding influence on the pulp strength, but steaming, evacuation,

and a higher cooking pressure increase considerably the folding strength. Using machine-chipped wood, the folding strength at 50° S.-R. has been raised from 1000–1500 to 2000–2600 by proper impregnation but, even so, the resulting pulp does not reach the folding strength of the hand-chipped wood pulp which, with no special

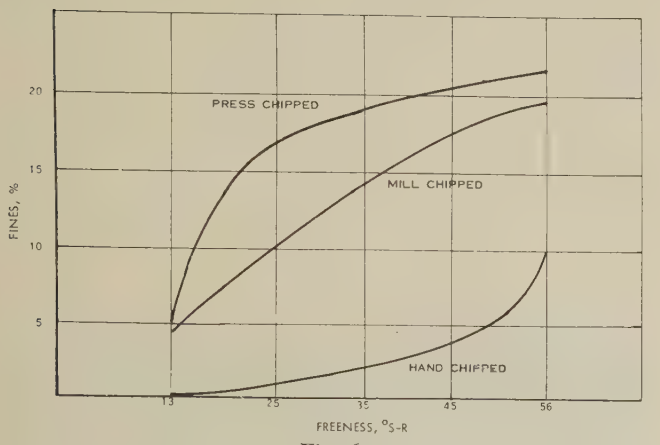

Fig. 6

impregnation, gives values of 4000 and more. This, of course, is true when delignification by sulphite liquor is carried out to a Roe number of 5 or less. Very hard-cooked pulps from machine-made chips and further delignified by chlorination also give pulps with 4000 or more double folds; these are the subject of the next study.

Although the fibers from handmade chips have a smooth surface, several irregular spots may be seen on the fiber surfaces from press and mill-chipped wood. The fibers are weakened at these places and, during beating, breakage occurs and, instead of fibrillated fibers, fiber fragments result.

Table XIII. Effect of Hand and Machine Chipping of Pulps Made from the Brazilian Tropical Hardwoods, *Vassorão* and *Tapixinqui*

Specimen		*Vassorão*	*Vassorão*	*Tapix-inqui*	*Tapix-inqui*
Chipping		Hand	Mill	Hand	Mill
Roe number		1.0	0.8	5.3	4.7
G.E. brightness, %		66	68	41	44
	S.-R.				
Valley beating time, min.	30	55	50	60	40
	42	70	65	81	55
	50	85	80	102	70
Tensile strength, m.	30	5200	5131	5656	4566
	42	5903	5428	5763	4620
	50	7071	6458	5833	4725
Double folds	30	697	377	329	57
	42	1050	540	372	216
	50	1343	649	490	254
Burst, kg./sq. cm. (100 g.)	30	3.4	3.2	3.0	2.1
	42	4.2	3.6	3.2	2.3
	50	4.3	4.0	3.4	2.4
Tear (Elmendorf), 100 g.	30	44.7	34.2	28.1	22.1
	42	41.7	27.0	24.3	19.8
	50	37.2	25.3	21.2	17.3

Table XII. Effect of Impregnation on Machine-Made Chips

Conditions: Sulphite acid: total SO_2, 4.3%; CaO, 0.98%. N = time of cooking, 3.5 hr. from 50 to 110°C.; 1 hr. at 110°C.; 3 hr. from 110 to 145°C.; 4 to 5 hr. at 145°C. NP = normal pressure 75 to 80 p.s.i. St = steaming. EP = elevated pressure, 100 to 110 p.s.i. V = evacuation.

Cook		82	93	76	77	83	85	75	87	79	80
Chipping		Mill	Mill	Mill	Mill	Mill	Mill	Mill	Mill	Mill	Mill
Kind of cook		N; NP	N; NP	N; St; NP	N; V; NP	N; St; V; NP	N; EP till 80°	N; EP at 145°	N; EP during the whole time	N; EP during the whole time	N; V 12 hr. at 50°
Yield, %		52.1	49.7	48.2	47.5	50.9	47.8	48.0	47.9	48.3	46.9
Screenings, %		2.7	1.6	0.8	2.0	1.2	0.6	1.4	1.9	1.8	1.0
G.E. brightness, %		43	47	48	48	44	44	49	45	46	48
Roe number		5.5	4.2	3.8	3.4	5.0	3.9	4.2	4.4	4.0	3.2
	S.R.										
Valley beating time, min.	55	56	58	53	51	53	55	55	50	53	55
Tensile strength, m.	25	5399	5800	4924	5482	4366	5888	5240	5961	5642	5249
	35	6166	6200	5721	6116	5933	7397	5999	6466	5946	6300
	55	6925	6500	5997	7374	6191	8211	6800	7520	6366	7258
Double folds	25	630	530	809	811	830	949	1087	964	1273	1036
	35	815	890	990	1010	1069	1388	1470	1380	1421	1504
	55	1244	1185	1526	1585	1574	2122	2100	1890	1812	2335
Burst, kg./sq. cm., 100 g.	25	3.32	3.53	3.08	3.52	3.60	3.88	3.70	3.88	3.69	3.76
	35	3.53	3.66	3.66	3.90	3.79	4.09	4.49	4.16	4.41	4.10
	55	3.90	3.86	4.21	4.10	4.19	4.27	4.59	4.48	4.61	4.63
Elmendorf tear, 100 g.	25	36.9	25.9	43.1	38.5	44.6	35.1	37.2	44.7	35.3	33.2
	35	31.2	20.9	38.7	25.9	31.0	27.9	31.6	36.0	32.3	30.9
	55	26.1	18.0	33.8	17.1	24.2	25.3	26.1	27.0	28.8	24.3

MICROSCOPIC STUDIES

The fibers from the pulps made from hand- and machine-chipped wood were photographed under the microscope with polarized light (see Figs. 7a, b, and Figs. 8a, b).

Data on the chemical composition of the pulp made from hand-chipped, press-chipped, and machine-chipped wood have been given in Table IX. There is a probability that the weakening of the fibers from mill-chipped wood is caused by the chemical action on the "weak spots"—perhaps in the amorphous regions, but this has not been definitely established as yet. The

Table XIV. Influence of Drying upon Properties of Pulps Made in Baskets in the Mill Digester from Handmade and Machine-Made Chips

Drying method		*Air dried at 45°C.*						*Air dried to 92% (bone dry)*					
Kind of beating		*Valley standard beater*						*Lampén mill*					
		Hand chipped			*Mill chipped*			*Hand chipped*			*Mill chipped*		
	S.-R.	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*
Tensile strength, m.	40	6485	6462	−0.4	5384	5111	− 5.1	5200	5236	+0.7	4942	3933	−20.4
	50	7722	7585	−1.8	6972	5833	−16.3	...	...	...	...	...	...
	65	7811	7512	−3.8	7054	6628	− 6.0	...	...	...	...	...	...
				−2.0			− 9.1						
Double folds	40	2914	2944	+1.0	1210	801	−33.8	4697	4640	−1.0	2466	225	−90.8
	50	4146	3904	−5.8	1712	1046	−38.9	...	...	...	...	...	...
	65	4910	4932	+0.5	2771	2174	−21.5	...	...	...	...	...	...
				−1.4			−31.4						
Burst, kg./sq. cm., 100 g.	40	4.5	4.6		3.3	2.9		3.7	3.6	...	3.0	2.5	...
	50	4.7	4.7		3.9	3.2		...	...	...	...	...	...
	65	5.4	5.2		4.1	3.5		...	...	...	...	...	...
Tear (Elmendorf), 100 g.	40	36	38		30	29		50	48		39	31	
	50	28	29		24	21		...	...	...	...	...	...
	65	25	26		21	18		...	...	...	...	...	...

higher yield, alpha-cellulose, viscosity, and pentosans could also be a result of the lower and slower delignification of the fibers from hand-chipped wood. Further work will be necessary to bring more light on this problem.

DECIDUOUS WOODS

It should be mentioned that similar differences were found between sulphite pulps made from hand- and machine-made chips of deciduous short-fibered woods growing in large quantity in the Brazilian forest. Two woods were tested: tapixinqui (*Croton floribundus*), which has an average fiber length of 1.35 mm., and vassorão (*Cletra brasiliensis*), which has an average fiber length of 1.35 mm. These two woods were chipped both by hand and by the mill chipper, and the chips were cooked in baskets in the mill sulphite digester. Results of the pulp tests are given in Table XIII.

The pulp made of hand-chipped wood of these trees also has higher strength (especially fold), and a longer beating time than pulp made from machine-chipped wood.

Table XV. Influence of Drying on Properties of Pulps Made in the Experimental Digester from Handmade and Machine-Made Chips

Cook		*122 (Mill chipped)*			*123 (Hand chipped)*		
	S.-R.	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*
Tensile strength, m.	20	4785	3499	−26.9	4450	4200	−5.6
	25	4847	3853	−20.5	6033	6193	+3.5
	35	4886	4128	−15.5	7694	7252	−5.8
	56	4827	4121	−14.6	6800	6394	−6.0
				−19.4			−3.5
Double folds	20	321	121	−62.3	2266	2144	−5.4
	25	583	258	−55.8	2750	2605	−5.3
	35	755	459	−39.2	2820	2701	−4.2
	56	879	685	−44.8	3382	3213	−5.0
				−50.5			−4.9
Burst, kg./sq. cm., 100 g.	20	2.8	2.3		4.9	4.6	
	25	3.5	2.6		5.2	5.0	
	35	3.6	2.7		6.6	6.5	
	56	3.4	3.0		6.0	5.9	
Tear (Elmendorf), 100 g.	20	39	35		39	38	
	25	31	30		33	31	
	35	25	28		28	28	
	56	29	31		27	25	

Air dried to 94% moisture-free.

SULPHATE PROCESS

No extensive investigation with sulphate pulping or

Table XVI. Effect of Impregnation on the Improvement of Physical Properties of Pulps Made from Machine-Made Chips Before and After Drying

N = normal cook. St = steamed before cooking. EP = elevated pressure.

			S.-R. = 25						*S.-R. = 55*					
		Max. temp., °C.	*Tensile strength*			*Double folds*			*Tensile strength*			*Double folds*		
Cook	*Kind of cook*		*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*
53	N	145	5208	3733	−29	1009	222	−78	7734	5100	−34	1369	806	−41
98	N; St	145	5342	4960	−18	770	218	−72	7205	4971	−31	1821	450	−75
76	N; St	145	4924	4480	− 9	809	526	−35	5997	4917	−18	1576	866	−45
87	N; EP[a]	145	5960	5121	−14	964	764	−21	7520	6117	−16	1890	1210	−36
61	N; St; EP[a]	140	6313	5755	− 9	1225	890	−28	8050	7162	−11	2682	2040	−24
102	N; St; EP[a]	130	6708	6180	− 8	1708	1362	−20	8242	7251	−12	2635	2225	−16
			Average		−14.5			−42.3			−20.3			−39.5

[a] During the whole cooking time.

prehydrolysis with hand- and mill-chipped wood have as yet been made, but there is a possibility that, especially during the prehydrolysis of hardwoods, the influence of chipping could be of importance. This influence is illustrated by experimental cooks in which machine-and hand-chipped eucalyptus wood was prehydrolyzed with water under pressure and the products were cooked together with sulphate liquor of 30% sulphidity. The results are:

	Yield, %	*Roe number*	*α-Cellulose, %*	*Pentosans, %*
Hand chipped	44	3.9	91.1	7.45
Machine chipped	42	3.1	90.6	5.58

The influence of hand chipping seems to be somewhat the same as in the case of sulphite cooking. Its degree may perhaps depend on the conditions under which the

Fig. 7a. Hand-made chips (without beating)

wood grows. Jayme and Groegaard (*8*) found that springwood is less resistant to mechanical pressure than the denser summerwood. This may also explain why the Scandinavian pulp is usually stronger than the pulp from Middle Europe when the same chipping method is used. The subtropical and tropical woods, whose trees have no or little winter rest, are apparently even more sensitive to the mechanical influence of chipping than is the wood from the cold regions.

EFFECT OF DRYING

In the beginning of this report the influence of drying on Paraná pine sulphite pulp was mentioned. In view

Fig. 7b. Hand-made chips (beaten to 40 S.-R.). Fraction passing 48 wire mesh and remaining on 100 wire mesh

of the fact that the pulp from the handmade chips appears to be more "healthy" than pulp from machine-

Fig. 8a. Mill-made chips (without beating)

made chips, it was interesting to investigate the influence of drying on this pulp. Table XIV contains some results of changes during the drying of these pulps cooked in perforated baskets in the mill digester.

It will be clearly evident that little significant change occurs in the strength properties on drying pulp from hand-chipped wood. Practically the same results were obtained on cooking hand-chipped wood in the experimental digester (Table XV).

Some improvement in the resistance to drying can be observed for pulps from machine-chipped wood, where special care was taken to impregnate the wood before actual cooking.

Fig. 8b. Mill-made chips (beaten to 40 S.-R.). Fraction passing 48 wire mesh and remaining on 100 wire mesh

At present it seems that the steaming of wood and a high initial pressure and a low temperature during cooking can, to a certain extent, compensate for the damage done to the wood by the mill chipper. How far the mill chipping itself could be improved cannot be foreseen at present.

To ascertain the difference between the behavior of the original and dried pulp made of hand-chipped and machine-chipped wood during beating, representative samples of these pulps were beaten in a Valley beater and the fiber length determined at different S.-R. freenesses on the Clark classifier. It was found that pulp from handmade chips, beaten wet and after drying, has practically the same amount of fiber fraction for the same freeness and practically requires the same time to reach the same degree of beating.

On the other hand, the dried pulp from mill-chipped wood disintegrates more rapidly during beating than the wet pulp and, at the same degree of freeness, has a greater percentage of short fibers. Also, the beating time necessary to reach the same beating degree is shorter for the dried pulp.

Table XVII. Change in Fiber Fraction Distribution as the Result of Beating Original and Dried Samples of Pulp Made from Hand- and Machine-Made Chips

	Hand chipped			*Mill chipped*		
S.-R.	*Original*	*Dried*	*Difference, %*	*Original*	*Dried*	*Difference, %*
			Residue on 14-Mesh Wire			
12	81.9	83.4	+1.8	60.5	62.2	+ 2.8
40	54.0	55.7	+3.2	27.5	20.5	−25.4
50	40.0	42.0	+5.0	25.9	18.5	−28.5
65	33.3	35.0	+5.1	16.2	10.2	−37.0
			+3.8			−22.1
			Residue on 28-Mesh Wire			
12	95.1	95.1	0	84.2	82.9	− 1.5
40	73.9	76.6	+3.7	50.4	45.5	− 9.7
50	59.5	63.1	+6.1	47.5	42.0	−11.6
65	53.3	55.0	+3.2	41.1	29.4	−28.5
			+3.3			−12.8
			Residue on 48-Mesh Wire			
12	97.8	98.4	+0.6	95.0	93.6	− 1.5
40	84.1	85.5	+1.3	69.3	68.5	− 1.2
50	73.9	77.0	+4.2	63.7	63.0	− 1.1
65	69.4	70.5	+1.6	63.2	54.0	−15.0
			+1.9			− 4.7
			Residue on 100-Mesh Wire			
12	99.6	99.4	−0.2	99.3	99.2	− 0.1
40	91.1	92.7	+1.8	86.7	86.5	− 0.2
50	86.7	85.6	−1.3	83.7	82.4	− 1.6
65	83.1	80.5	−3.1	81.6	74.9	− 8.2
			−1.5			− 2.5

The corresponding beating times are shown in Table XVIII.

Table XVII gives the percentage of fibers left on sieves Nos. 14, 28, 48, and 100 at the same freeness.

Table XVIII. Time to Reach a Given Freeness in Beating Pulps Made from Hand- and Machine-Made Chips, Before and After Drying

Beating time in runs from S.-R. = 12

	Mill chipped		*Hand chipped*	
S.-R.	*Original*	*Dried*	*Original*	*Dried*
38	18	15	20	20
50	23	20	25	25
65	28	24	35	35

Note: Dried pulp was soaked in water 2 hr. before beating.

These experiments show that the strength loss of the dried pulp is caused in the first case by the breakage of the fibers during the beating.

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Pulping Studies with African Tropical Woods

R. PETERI

THE continuous increase in the world's need for pulp and paper products has induced the scientific and industrial research institutes and laboratories to study methods which might effect an improvement in the pulp supply for paper and cellulose derivatives.

The increase in cellulose resources may be obtained by three means: (1) by improving present-known processes or by developing new ones for increasing the yield of raw materials for papermaking—the different semi-chemical processes specially aim at this purpose, (2) by improving the papermaking qualities and particularly the strength characteristics of pulps, which would make it possible to utilize papers of lower basis weight for the same use and thus indirectly increase the supply for the world's paper markets, (3) by considering the use of fibrous raw materials as yet not used or only slightly used by the pulp and paper industry.

Among these new raw materials, important research and even industrial work has been done on the different straws and deciduous woods of the temperate countries.

If the favorable outcome of these investigations makes it possible to resolve, in the immediate future, the problems of supply of the world's papermaking industry, their effect would not be lasting and even if the paper consumption increases only at the same rate as during the last few years—and it may be supposed that it will even increase more—the scarcity in cellulosic materials would reappear after a very short time. On the other hand, the use of the resources of the tropical forests would have a more stable effect.

The first research on the use of tropical woods for pulp and papermaking lasted until the beginning of the century and was undertaken by several countries. One can mention the investigations of the Belgians, the English, the Germans, the Swiss, and so on.

In France, important studies were carried out between the two wars, and specially at the French papermaking school (École Française de Papeterie) at Grenoble. These studies, like those of other countries, sometimes led to interesting results, but did not allow the development of the cellulose industry in the tropics.

Indeed, nearly all this work was done only with certain species chosen from the tropical forests, the quantities of which were not great enough, considering the great exploitation difficulties, to supply important pulp mills.

Since 1939, the French Government has recognized the importance that the tropical forests can play in the papermaking industry and, after having planned the installation of a mill based on the use of the *Musanga smithii* (umbrella tree), it entrusted the setting up of a pilot plant in tropical countries to a public establishment specially created for this purpose in 1944, the Régie Industrielle de la Cellulose Coloniale (R. I. C. C.).

In this organization, under the authority of the French Overseas Territories Department (Ministère de la France d'Outre-Mer) are represented, in addition to the public authorities, the most qualified persons of the French pulp and paper industry. Its essential aim is "the study and the experimental exploitation, on an industrial scale, of the products of African forests and savannahs, specially for paper and pulp making."

The activities of the R. I. C. C. may be divided into four groups: forest prospecting, studies and research, industrial experiments, and creation of a pilot plant.

FOREST PROSPECTING

The creation of a cellulose industry in tropical countries involves, first of all, the exact knowledge of the raw materials at one's disposal.

For this purpose, the R.I.C.C. created two forest study missions: the first in French Equatorial Africa and the second in French West Africa; its work was concentrated in the forests of the region of Abidjan on the Ivory Coast. In addition to this, it collaborates closely with the forest services of the overseas territories.

Very extensive counting was done in the forests. The results of this work allowed the following conclusions to be drawn: The heterogeneity of these forests is such that it is practically impossible to provide a pulp mill, even of average size, with wood from one or a few chosen species. Although the number of species which can be found in tropical forests covering an area of several thousand acres may reach or even exceed 200—the number of species of tropical woods is above 5000—only about 20 species can be considered as predominant and they generally constitute more than 80% of the forest examined.

Before planning the utilization of a forest for supplying a pulp mill, it is therefore important to know: The yield of the forest—that is, the amount of available wood per unit of area. The average composition of the forest.

From the results of the countings, it has been found that, even with summary countings, covering only about 1% of the total area of the forest but chosen in a systematic manner, the yield of the forest per unit of area can be determined with sufficient precision, the difference being not over 10%.

On the other hand, if one wants to know the composition of the forest, which is essential for adapting the mechanical as well as the chemical methods of pulping, a more extended study has to be made and, depending on conditions, 5 to 20% of the wooded area must be inventoried.

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If the counting is carried out on a tropical forest of (if it can be said) homogeneous heterogeneity—that is, if the average composition of the parcels varies little when passing from one extremity of the forest to the other—an average composition of the whole forest can be established.

On the contrary, in many cases, when geographical conditions of the forest, as a result of topographical accidents, vary in the same forest, the composition undergoes important fluctuations. In this case, the average composition has to be established for areas corresponding to 1 or 2 years of production of the planned mill.

These forest investigations are unfortunately very long and expensive but it can be noted that the advantages, and especially the great security of working which can be obtained with these forest studies, fully justify the cost. This charge, reported per ton of pulp produced, constitutes only a relatively moderate part of the cost price.

Before the establishment of any mill it is very important to make an exact inventory of fibrous materials, to evaluate the amount available, and to know the average composition.

STUDIES AND RESEARCH

At the beginning of the work of the laboratories of the R. I. C. C., individual studies of certain tropical species (particularly the umbrella tree and the okumé) were undertaken; however, since the very intricate composition of tropical forests has been known, the investigations have been directed toward the use of the tropical forest in its present heterogeneity.

The only practical solution, the cooking of a mixture of very different woods, was first tried on arbitrary blends; the favorable results were then verified on mixtures corresponding to the average composition of tropical forests, determined from the countings of the forest study missions.

Tropical woods differ chemically and physically from those of temperate countries and, consequently, they have to be treated under other conditions. The methods elaborated for softwoods and European or American hardwoods are not necessarily the best ones for tropical woods.

The sulphite process, when it is used in the treatment of softwoods has its chief interest in the high yield and the light color of the pulps obtained. The results with the tropical woods studied are different: the yields are mediocre, the pulps are often dark, and the strength properties are largely reduced by the strong attack on the cellulose wall.

The soda process, even though it may give better results in the individual treatment of tropical species, does not seem to be suitable for the cooking of tropical hardwood mixtures.

On the contrary, the use of the alkaline sulphate process, which can be adapted to the nature of the woods forming the mixture, gives very good results and makes it possible to obtain pulps from tropical woods which, for many uses, can compete favorably with softwood pulps of temperate countries.

Pulping Very Different Woods

The simultaneous treatment of very different woods does not offer any inconvenience; on the contrary, several advantages can be shown.

Reduction of the Ratio of Necessary Chemicals. During the laboratory studies it was established that the simultaneous treatment of species which needs different percentages of cooking agents in individual cookings gives the best quantitative and qualitative results by the use of conditions corresponding approximately to the most easily cooked species. The economy of chemicals realized by this means reaches and may exceed 10%.

Increase of the Yield. Since the cooking conditions are more moderate than the average of the conditions for each species forming the mixture, the result is a slighter attack on the cellulose and thus an increase in the yield.

Increase of the Papermaking Qualities. This increase is due both to the milder treatment and the presence of different fibers.

In softwoods there are two kinds of fibers: the spring fibers with thin walls and the autumn fibers with thick walls; this distinction is not seen in the tropical hardwoods. It has been established by several authors that the presence of the two kinds of fibers in softwoods is one of the reasons for the superiority of these pulps over hardwood pulps, probably because of a better interweaving during sheet formation.

Generally, the presence of the fibers of one type in deciduous woods was considered an inconvenience. By using a mixture of deciduous woods, this inconvenience can be eliminated. Indeed, some species have fibers with thin walls corresponding to the spring fibers, whereas other fibers have thick walls like the autumn fibers.

Nearly Universal Quality of the Pulps. The investigations demonstrated that tropical woods cooked in mixtures can furnish an unbleached pulp of good quality which is suitable for almost every wrapping paper (kraft and others). In addition, they are able to give a bleached pulp meeting almost all the advantages of bleached softwood and esparto pulps. This pulp is particularly convenient for book papers and fine printings.

Biometric Properties

Special attention was paid to the influence of the biometric properties of the different species present in the forests studied. It is well known that, until recently, most of the papermakers considered (and some of them still believe) that the manufacture of a paper with good strength properties necessarily needs the use of long-fibered pulp and that hardwood pulps, chiefly with short fibers, can be used only as a secondary and specially as a filling pulp. During the investigations made in the laboratories of the R. I. C. C. no relation was found between the length of the fibers and the tensile and the bursting strengths.

On the contrary, these two properties are greatly influenced and the first is directly determined by another factor called by the R. I. C. C. "the coefficient of flexibility." This is the ratio (as a percentage) between the diameter of the cavity and the width of the fiber.

When studying the influence of the length of the fibers on the tearing strength, no direct relation was

found. Pulps having fibers of about 1 mm. in length, such as *Dacryodes klaineana*, give papers of a higher tearing strength than those given by pulps with fibers of 2.5 mm., such as *Uapaca*.

But if a graph is made of the tearing strength as a function of the relative length of the fiber as compared with its width—a coefficient currently called "felting power"—it can be noted that the points are disposed around a line, with a dispersion of about 20%.

These two experimental laws, established from about 50 studies and verified on several species, consequently make it possible to foresee with a sufficient degree of accuracy the papermaking properties that a given species or mixture possesses if the chemical treatment is carried out under the best conditions.

But if the average length of the fibers is under a certain critical value, which is placed between 700 and 900 mu, it brings a very marked harmful influence on the strength properties and the above laws cannot be applied.

Chemical Analyses

Numerous chemical analyses were also carried out in order to ascertain whether the chemical composition of woods is a guide to the treatment to be applied during cooking. This investigation ended in a negative conclusion: The chemical composition of woods does not seem to have any influence or, perhaps, only a very slight influence on the cooking conditions. A qualitative study would have probably given more positive results but this work could not be attempted.

Although the work carried out by the Research Department of the R. I. C. C. was especially concentrated on chemical pulp, investigations were also undertaken for preparing semichemical and dissolving pulps.

Semichemical Pulping

In the case of semichemical pulps, the first results are encouraging. High-yield pulps (about 85%) with satisfactory papermaking properties, although generally dark colored, could be obtained from tropical hardwood mixtures.

The various known semichemical processes were also investigated. Some of them, such as the alkaline processes, gave satisfactory results; others, like the neutral sulphite process, do not seem to be suitable for the tropical woods studied.

Dissolving Pulps

The research work on the utilization of tropical woods for dissolving pulps is only in its infancy; the difficulties are great and result chiefly from the high pentosans and ash contents (especially silica) of tropical woods.

Forest Cultivation

Although the idea of using one particular tropical species has entirely been given up, the thorough study of the predominant species found in the different tropical forests has not been neglected.

Indeed, if it is possible to use the tropical forest in its present heterogeneity by the elaborated process, the regeneration of the forests of course will not be done at random, but directed so as to obtain the best results, both for yield and for papermaking properties.

This regeneration of the forest is a very delicate problem which cannot be investigated in the laboratory; its study could be undertaken only when forest exploitation has been started.

Nevertheless, one can affirm forthwith that as well for forestry as for papermaking reasons, the creation of homogeneous forests is not to be foreseen. Work has to be conducted in order to obtain a forest of a determined heterogeneity.

To be able to ascertain the composition of this new forest, it is indispensable to know the papermaking properties of the species most frequently met with in the geographical and climatical conditions of the forest investigated and to choose from among these species those which give the best results in yield and papermaking facilities.

For this purpose, about 100 species were individually investigated and a list of "papermaking species" established.

INDUSTRIAL TRIALS

In order to verify the processes elaborated on the laboratory scale, the Régie Industrielle de la Cellulose Coloniale decided to conduct trials on an industrial scale during the years 1948 and 1950.

For this purpose about 300 metric tons of wood, representing the average composition of different tropical forests, were transported to France and pulped in several mills. Unbleached and bleached pulps were manufactured and transformed into more than 30 different kinds of papers. No particular technical difficulties were encountered during these trials.

The qualities of the tropical pulps could be demonstrated during the various runs. Among these, one can indicate their use for kraft papers for cement bags, machine-glazed and dry finish kraft papers of a basis weight of from 50 to 120 g. per sq. in., specially thin papers, writing and book papers, and blotting papers.

THE PILOT PLANT

In order to create large production units in the tropical countries of the French Oversea Territories, the Public Authorities judged it essential to create a pilot plant. Its primary purposes are: the adjustment of the processes elaborated on the laboratory scale and the technical and economic investigation of the exploitation of a pulp and paper mill in the tropical region.

The setting up of such a plant, even if small, in the Tropics is not without difficulties.

In these countries, which are industrially underdeveloped, the mill cannot rely on any outside help, being several thousand miles from the nearest industrial centers. Consequently, it has to have an almost total working autonomy. This distance even makes its construction very difficult. All the construction raw materials and all the machinery must be imported and very often under very adverse conditions.

The working of the mill, which must be highly automatic, raises great problems. Local labor, having no technical ability, cannot be employed like workers of industrially developed countries and must be strongly

supported by European experts and specialists. The recruitment of this staff is not without obstacles because of the particular climate of these countries.

It was under these difficult conditions that it was decided to erect the pilot plant at Bimbresso near Abidjan on the Ivory Coast, French West Africa.

This plant, on the banks of the Ebrié lagoon, receives the fibrous raw materials from the forest of Anguédédou, connected to it by a road of about 6 km. The forest, with an area of 8400 hectares, is, on the whole, a primary or an old secondary one.

For a production of 6000 tons a year, the pilot plant consumes about 20,000 tons of pulpwood. For the supply of this quantity—which perhaps would seem low for a plant in a temperate country, but which is very large on the African scale—the plant has its own forest exploitation which, in its kind, must be considered as a pilot exploitation. Indeed, if a certain practice is already established for the exploitation of timber and noble woods in the tropical countries, the information obtained, although valuable, does not allow the numerous problems raised by the production of pulpwoods to be resolved.

The first exclusively chooses trees having large diameters (over 0.80 m.) and fells only a small number of trees per hectare, whereas the second uses all the different woods, independently of their diameter and nature, and leaves only those species of timber whose utilization as pulpwood is not economical.

The felling, loading, and handling problems which, even in the most developed countries, are far from being solved, are consequently of a quite different nature. At the present time, there is no equipment (such as tractors, moving cranes, or winches) specially adapted to these conditions. As a consequence, the work of the pilot exploitation consists of choosing from the existing machines the most convenient ones and adapting them to the needs and the conditions of the local labor, thus making it possible to ensure the supply of wood for the plant at every stage of exploitation.

One of the most important problems to be resolved is the chipping of the logs. These woods are physically very heterogeneous and a large part of them are very hard. In addition, some woods have very high silica contents, far greater than those of woods in the temperate countries.

The plant is provided with two chippers, each one having four knives; they are driven by motors of 125 and 300 h.p., respectively.

The chips are transported from the chipper to the three rotary digesters of 30 cu. m. by a pneumatic system. The pulp, washed on a zone filter, is continuously beaten, either in conical refiners or in such refiners connected with two hollanders, each one with a capacity of 500 kg.

The plant has a paper machine with a useful width of 2.40 m., capable of running 150 meters per minute and to produce papers of about 40 to 300 grams in basis weight. The arrangement of this machine is such that it is very adaptable, its chief aim being the experimental production of paper from tropical pulps.

In addition, the plant is provided with the necessary machines for the making of sewn or pricked multi-ply cement bags.

Having no source of hydraulic power at its disposal, the plant has a large thermo-electric station of 3000 kw. For heating, both wood and fuel oil are used. It has a pumping station which can reach a flow of 2000 cubic meters per hour.

In consequence of the great distance from industrial centers, not only the maintenance but also any repairs have to be made by the employees of the mill. Consequently, it has very specialized mechanical workshops.

The pulp mill opened in April of this year. It must progressively reach a production of 500 tons a month, corresponding to the normal working of the plant.

The papermaking machine was ready for use in the middle of July. Bagmaking will start at the end of the year.

The qualities of the pulp made at the pilot plant completely verify the results obtained during research and industrial trials.

At present, no information can be given on the economical working of the plant. The cost price will be calculated only when the production of the installation has reached its full capacity and then over a sufficiently long trial period.

If the R. I. C. C. has concentrated all its efforts during these last years on the establishment and the starting of the pilot plant, it has not lost sight of the fact that the problems of the evaluation of the tropical forest and of the world scarcity in cellulose can be solved only by large production units. In fact, the industrial autonomy imposed by the great distance of the mill from centers of any importance burdens the establishment and the working budget of a tropical mill. However, if such a plant is to be economically sound, its productive capacity must be sufficiently high.

The size of such a plant cannot be fixed *a priori*. It is influenced by numerous factors, such as the site, the supply of raw materials (wood and chemicals), the possibilities of the disposal of finished products (in the country or outside), the availability of a cheap source of energy, and so on.

Nevertheless, one may admit that, even in very favorable cases, a tropical pulp mill must produce at least 50,000 metric tons of pulp a year. In certain cases this production should reach and perhaps exceed 100,000 metric tons.

The local market is very small and it will remain so for quite a long period. The production of the future tropical pulp mills must be directed towards the markets of countries of high industrial potential, such as Europe and America.

To be able to support the high transport costs of export, the finished products must be of high value, such as bleached chemical or semichemical pulps, dissolving pulps or possibly, in certain economic circumstances, papers.

The establishment of these plants obviously involves the investment of a great deal of capital. However, the results which have been obtained thus far appear to justify the efforts which must be expended.

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Colonial Tropical Hardwoods as Papermaking Materials

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As long ago as 1903, the laboratories of the Colonial Products Advisory Bureau, which functioned until 1949 as the Imperial Institute, were examining materials from colonial sources with a view of determining their papermaking properties and were, indeed, pioneers in this connection. A large proportion of the materials investigated during the period covered by this paper have been derived from fibrous plants and interest in woods has been very secondary, mainly because of the supremacy of coniferous woods for papermaking. It is disturbing to find, now that interest has been focused on tropical hardwoods, how little scientific data are available on colonial hardwoods, and that much of the material we are now receiving for examination requires to be investigated *ab initio*. We have been able, however, over the period of time to gather a considerable amount of general information which can help toward the assessment of the papermaking properties of tropical hardwoods. We know, for instance, that on the whole the ultimate fibers of these woods are only about half the length of the conifers and, for this reason, cannot be expected to yield unprocessed pulps of more than moderate strength; also, that many of them contain a relatively high proportion of resins, a feature which increases the quantity of chemicals necessary for pulping.

Before dealing specifically with the tropical hardwoods examined in its laboratories, I should like to outline briefly the functions of the Colonial Products Advisory Bureau in order that the type of problem with which it deals may be fully appreciated. The Bureau is a part of the Colonial Office in London and is called upon to advise on matters concerning the development and the industrial use of the raw materials of the British Colonies. Obviously, scientific and technical aspects are very important features but these have to be integrated also with existing economic conditions. In the past, these have been unfavorable to the setting up of an industry in the Colonies for either hardwoods or pulp for export. At the present time, when there is an acute shortage of both raw materials and pulp required for the manufacture of paper, fiberboard, and rayon in the United Kingdom, the Bureau receives a large number of requests for advice as to the possibility of using colonial hardwoods in all three industries.

In the first place, it is obviously necessary to determine which colonial hardwoods are suitable for the manufacture of cellulose products and, if so, for what grades. As I have already stated, this information is very incomplete and, to overcome the difficulties caused by this lack of comprehensive data, it is necessary to institute a sorting procedure which, although not infallible, will yield fairly reliable data on which to express an opinion.

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The authorities in the Colonies are being informed that the most promising materials for pulp production may be found among the soft hardwoods and they are being asked, therefore, to submit samples of quick-growing species with a low resin content.

In the laboratory a preliminary investigation of the material, which includes the microscopical examination and measurement of the ultimate fibers, the determination of ash, resin (including waxes and fats), alkali solubility (1% NaOH for 1 hour at 100° C.), and cellulose, followed possibly by a single soda boil under average cooking conditions, usually yields enough evidence to decide whether it is worth while to proceed with a comprehensive examination of the sample.

A more comprehensive investigation is carried out on those samples which show promise. The procedure is never rigid, and may vary considerably according to the data obtained during the progress of the work. The over-all pattern is, however, similar in each case, and aims at determining the optimum cooking conditions by either the soda or sulphite process or both, followed by an assessment of the strength of the pulps and their response to beating. Bleaching trials are also carried out on most samples and, since we have to consider the demands of the rayon industry, the alpha-, beta-, and gamma-celluloses are determined on pulps from woods which yield a relatively high cellulose figure in the preliminary examination.

Once it has been determined in the laboratory that a sample exhibits satisfactory qualities for papermaking, consideration has to be given to the many factors concerned with the establishment of an industry. It is impossible, in this paper, to discuss these in detail, and I will only refer to the need for mill trials on a sample consignment, and a thorough survey of the amount and availability of the timber in order to determine whether the stands are sufficient to furnish ample supplies over a long period at a reasonable cost. Availability of water, power, and transport facilities are also serious problems, and the difficulty of coordinating all these requirements has hampered the development of a papermaking industry in colonial territories.

Turning now to our experience in the investigation of colonial tropical hardwoods, I shall divide this into two periods of time, the first covering the years up to 1938 before standard testing equipment was installed in the laboratories, and the second, from 1938 to date, during which the evaluation of pulp had been carried out on standard sheets prepared and tested according to the official methods described in the Second Report of the Pulp Evaluation Committee of the Paper Makers' Association, a title which has now been changed to the British Paper and Board Makers' Association.

Between the years 1924 and 1928, 21 timbers commonly occurring in British Guiana (*1*, *2*) were examined at the Imperial Institute. Moisture, ash, and cellulose were determined, and papermaking trials

were carried out in the laboratories by treating the wood with caustic soda under conditions similar to those employed for the production of paper pulp on a commercial scale. The samples tested included greenheart (*Ocotea rodiei*) and wallaba (*Eperua falcata*). The cellulose content expressed on moisture-free wood varied from 40 to 61%, the lowest yield being that obtained from the wallaba. Pulp yields of unbleached pulp varied from 28 to 49%.

As a result of the examination, it was considered that many of the woods would furnish, on the whole, good yields of well-digested pulp with comparatively low consumption of soda. The lowest yields of pulp were obtained from ite or aeta (*Mauritia flexuosa*), wallaba, and trysil (*Pentaclethra filamentosa*) which yielded 27, 37, and 38%, respectively.

The dimensions of the ultimate fibers determined on 10 of the samples varied from a maximum of 2.0 mm. to a minimum of 0.6 mm. The average over the whole range of samples was approximately 1.4 mm.

A second investigation on wallaba wood from British Guiana (*3*) was carried out in 1930. Chemical analysis showed this sample to contain 55% of cellulose (expressed on the moisture-free wood) as compared with 40% found previously. The range of ultimate fiber lengths was from 0.9 to 2.4 mm., with an average of 1.5 mm. As might be expected, this sample gave a higher yield of pulp, 45% as compared with 37%, and it was thought that this might be due to a difference in age of the wood, as the first sample consisted of a log only $6^1/_2$ inches in diameter, whereas the second had a diameter of $10^1/_2$ inches. Papers prepared from the pulps were soft, rather bulky, and of fairly good strength. An attempt to pulp the wood by the sulphite process failed, and it was considered that this was due to the presence of about 12% of resin.

To complete the story of wallaba, I should like to refer to the very comprehensive investigation carried out by Cross and Bevan, London, who showed that the sulphate pulping method could be applied to British Guiana wallaba and the woods associated with it in the forest, to yield pulps which, although having greater strength than those obtained from soda cooking, would still have only limited applicablity in papermaking. It was considered at the time that any project for pulping the wood would be uneconomic unless undertaken

Table I-a. Microscopical and Chemical Characteristics

Material and origin	Moisture, %	Chemical analysis on moisture-free wood: Ash, %	Resin,[a] %	Alkali solubility,[b] %	Cellulose,[c] %	Ultimate fibre dimensions: Average length, mm.	Average diameter, mu
British Guiana							
Bara-bara (*Diospyros guianensis*)	13.6	0.6	...	...	58.2	0.9	..
Baramalli (*Tabebuia sp.* ?)	13.0	1.2	...	...	58.2	1.9	..
Fotui (*Jacaranda copaia*)	23.4	0.6	...	...	58.9	0.95	..
Haiari-balli (*Diplotropis sp.*?)	20.2	0.4	...	...	50.6	1.3	..
Hog plum (*Spondias lutea*)	14.6	1.0	...	...	53.7	1.1	..
Hurowassa (*Pithecolobium trapezifolium*)	35.4	0.9	...	...	49.2	0.9	..
Karahora (*Schefflera depressa*)	15.0	0.6	...	...	56.0	1.0	..
Kurukoruru (*Diplotropis sp.*?)	17.2	0.4	...	...	59.4	1.3	..
Long John (*Triplaris surinamensis*)	16.1	1.2	...	...	55.7	0.9	..
Wanasoro (*Cecropia juranyiana*)	11.8	2.1	...	...	61.3	1.1	..
Greenheart (*Ocotea rodiei*)	13.0	0.48	...	...	54.8	1.2	15
Wallaba (*Eperua falcata*) 1st sample	16.7	0.58	...	...	39.7	1.4	15
Kakaralli (*Eschweilera laevifolia*)	13.7	1.8	...	...	49.6	1.6	18
Mora (*Dimorphandra mora*)	11.6	0.5	...	...	53.3	1.5	17
Yaruru (*Aspidosperma excelsum*)	9.6	0.64	...	...	52.1	1.5	21
Itikibouroballi (?)	12.7	0.57	...	...	59.5	1.1	19
Trysil (*Pentaclethra filamentosa*)	15.5	0.4	...	...	50.4	1.2	18
Marishiballi (?)	16.2	1.4	...	...	62.4	1.5	17
Kautaballi (*Licania venosa*)	10.7	1.4	...	...	61.8	1.8	20
Morabukea (?)	14.0	0.4	...	...	58.8	1.2	17
Moraballi (*Peltogyne* ?)	12.6	0.8	...	...	55.4	1.1	22
Wallaba (*Eperua falcata*) 2nd sample	8.8	0.9	...	...	55.3	1.5	18
British Honduras							
Quam (*Schizolobium sp.*)	10.8	1.0	...	...	58.7	1.2	..
White moho (*Hibiscus sp.*)	8.5	0.5	...	...	57.0	1.6	..
Polak (*Ochroma sp.*)							
(a) hard	9.3	0.8	...	...	53.9	1.8	..
(b) soft	8.6	1.0	...	...	51.9	1.6	..
Nigeria							
Abura (*Mitragyna macrophylla*)	12.3	1.3	...	...	52.0	1.6	..
Afara (*Terminalia superba*)	10.5	2.2	...	...	51.6	1.2	..
Oro (*Irvingia barteri*)	10.3	1.7	...	...	48.8	1.5	..
Arere (*Triplochiton nigericum*)	9.7	1.3	...	...	50.0	1.4	..
Ogia (*Daniella ogea*) I	9.7	0.4	...	...	46.8	1.5	..
Ogia (*Daniella ogea*) II	11.2	2.8	...	...	48.2	1.5	..
Trinidad							
Acurel (*Trichilia oblanceolata*)	11.8	1.1	...	...	57.1	1.6	16
Hog plum (*Spondias mombin*)	10.6	1.0	...	...	56.6	1.5	28
Yellow manguo (*Symphonia globulifera*)	10.6	0.5	...	...	59.6	1.6	20
Wild chataigne (*Pachira insignis*)	11.2	2.4	...	...	52.4	2.2	25
Jigger (*Bravaisia floribunda*)	11.6	4.2	...	...	57.8	1.4	22
Bois mulatre (*Pentaclethra filamentosa*)	9.0	0.2	...	...	57.6	1.3	22
Mahoe (*Sterculia caribaea*)	10.7	1.4	...	...	60.8	2.1	24
South Africa							
Eucalyptus saligna	10.8	0.7	13.6	13.2	54.9	1.0	19
Tanganyika							
Brachystegia sp. I	6.9	1.9	0.5	12.3	58.8	1.2	13
Brachystegia sp. II	8.2	1.7	3.5	21.4	51.4	1.0	12

[a] Solubility in alcohol-benzene. [b] 1% NaOH for 1 hr. at 100°C. [c] Cross and Bevan.

as part of a general development scheme which would spread the capital cost involved over other fields.

In 1925 an investigation was made of three woods from British Honduras (*4*). The Conservator of Forests considered that it might be worth while to cultivate the trees in certain places on a short rotation as sources of paper pulp. Laboratory trials showed that two of the samples [quam wood (*Schizolobium sp.*) and white moho (*Hibiscus sp.*)] contained 59 and 57% cellulose, respectively (calculated on the moisture-free wood). The third sample, named polak and stated to be a species of *Ochroma*, varied considerably in hardness, the center portion of the logs being soft and light and the outer portions harder and heavier. The soft and hard portions, containing 54 and 52% cellulose, respectively, were examined separately. The results showed that quam wood and white moho yielded 47 and 52% of unbleached air-dry pulp under moderate conditions of cooking with soda, the white moho pulp being of rather better quality and more easily bleached. It was considered that both pulps would furnish paper of satisfactory quality. It was found that polak wood presented a difficulty owing to the variation in density in different parts of the trunk which, apparently, does not occur to the same degree in all trees. The hardwood from polak will furnish a fairly satisfactory paper pulp, but the presence of a large proportion of the softwood would impair its quality.

Five samples of wood from Nigeria were examined in 1926 with a view of determining their possible value for the manufacture of paper pulp (*5*). Analysis showed them to contain from 47 to 52% of cellulose. The ultimate fibers varied from 0.7 to 4 mm. in length, and the averages for the samples were 1.6, 1.2, 1.5, 1.4, and 1.5 mm., respectively. All five samples of wood furnished short-fibered pulps, although the average lengths of the ultimate fibers were on the whole higher than those from poplar (*Populus tremuloides*), which is approximately 1.2 mm. None of the pulp yields was high and, with the exception of one sample [abura (*Mitragyna macrophylla*)], more drastic conditions of digestion were required than are usually found necessary for such materials. The pulps were difficult to bleach, and in no case was a good white paper produced.

The only other reference I shall make to work carried out prior to 1938 is to an investigation carried out for the Conservator of Forests, Trinidad (*6*) on seven of the more abundant woods which, it was hoped, might be suitable for papermaking. The average ultimate fiber length in each case was rather higher than for poplar, and varied from 1.3 to 1.6 mm. All the samples pulped fairly easily, and gave pulp yields varying from 46 to 57% of moisture-free pulp (expressed on the moisture-free wood).

Wild chataigne wood (*Pachira insignis*) and mahoe (*Sterculia caribaea*) yielded the longest-fibered pulps, and produced rather better papers than any of the other samples; also, the amounts of caustic soda consumed were appreciably lower than in the case of the other samples, with one exception.

Proceeding to the period after 1938, I should like to refer to two investigations which I consider give a good indication of the contrasting results that may be expected from colonial tropical timbers.

Eucalyptus saligna is indigenous to the semitropical regions of New South Wales and Southern Queensland, where it is known as Sydney blue gum. The oldest trees in South Africa are only about 40 years old; 10,000 acres have been devoted to the growing of this tree by the Department of Forestry, Union of South Africa. It is a quick-growing tree and in favorable localities grows 8 feet in height and 1 inch in diameter each year. It thrives in all moist mountain and subtropical areas of the Union and produces clean straight stems. In recent years this tree has been planted extensively by private enterprise, almost exclusively to provide pit props and other mining timber. Large areas have been planted in Zululand and Northeastern Transvaal, and it has been successfully introduced into Uganda, Kenya, Tanganyika, and recently, into Nigeria.

In view of the ease with which *E. saligna* can be grown in South Africa, a sample was examined (*7*) in 1946 to ascertain the suitability of this wood as a source of pulp for papermaking and for the manufacture of artificial silk.

The apparent density of the wood at 11.6% moisture was 41.8 pounds per cubic foot. The estimated maximum age of the wood as represented by the annual rings was 7 years.

A chemical examination of the sample showed it to contain 13.6% resin, 54.9% cellulose, and an alkali solubility of 13.2% (all expressed on the moisture-free material). It was considered that the wood possessed a satisfactorily high cellulose content, a satisfactorily low alkali solubility, and a high resin content from the papermaking point of view. The average length of the ultimate fibers was 1.0 mm. Under the microscope the fibers appeared as thin-walled, flattened cells with very tapering ends.

The wood was found to be readily pulped by the soda process, the yield under the best conditions of cook being 58% (calculated on the moisture-free wood). Evaluation of the pulp by the methods already referred to showed that the breaking length, burst factor, and tear factor were all low, and the pulp was considered weak in character. The pulp was difficult to bleach in one single stage. A study of the effect of beating the pulp proved most interesting; the strength of the material as measured by the breaking length, burst factor, and tear factor was considerably increased by beating treatment; the response was somewhat similar to that of medium-strength commercial kraft pulp.

Pulping trials using the sulphite process showed that the wood could be pulped satisfactorily by this method, and an evaluation of the pulps showed them to have characteristics similar to those obtained by the soda process. The pulps were again found difficult to bleach.

The sulphite pulps responded to beating in much the same manner as did the soda pulp, but to a somewhat lesser extent. An analysis of one of the sulphite pulps showed it to contain 87.8% alpha-cellulose, 3.0% beta-cellulose, and 6.7% gamma-cellulose, and 1.5% ash (calculated on the moisture-free pulp). It was considered, therefore, that if the wood was submitted to a more drastic treatment, the alpha-cellulose could be increased to a level which would be satisfactory for the artificial silk industry.

Species of *Brachystegia* are widely distributed in tropical Africa; they will be found as far north as Nigeria

Table I-b. Pulping Characteristics

Material and origin	Soda cooks; conditions which gave a well-digested pulp: Maximum temperature, °C.	Time at maximum temperature, hr.	Strength of caustic soda solution, %	Caustic soda per 100 parts moisture-free wood, parts	Caustic soda consumed per 100 parts moisture-free wood, parts	Yield of unbleached moisture-free pulp on moisture-free wood, %	Paper furnished
British Guiana							
Bara-bara (*Diospyros guianensis*)	160	9	4	20	14.1	47	Brown paper of good strength
Baramalli (*Tabebuia sp.?*)	160	9	4	20	13.0	42	Unbleached, fair strength with some shive; bleached, similar but no shive
Fotui (*Jacaranda copaia*)	160	6	4	20	9.9	46	Strong, pale brown paper
Haiari-balli (*Diplotropis sp.?*)	160	6	4	20	10.4	41	Moderately strong, rather speckled, grayish-brown paper
Hog plum (*Spondias lutea*)	160	9	4	20	14.9	40	Strong, brown paper with few specks
Hurowassa (*Pithecolobium trapezifolium*)	160	6	4	20	9.2	31	Pale brown paper of fair strength
Karahora (*Schefflera depressa*)	160	6	4	20	11.6	49	Strong, pale brown paper
Kurukoruru (*Diplotropis sp.?*)	160	9	4	20	11.2	41	Soft, pale brown paper of good strength
Long John (*Triplaris surinamensis*)	160	9	4	20	13.2	38	Light pinkish-brown paper of fair strength
Wanasoro (*Cecropia juranyiana*)	160	9	4	24	14.5	47	Brown paper of good strength
Greenheart (*Ocotea rodiei*)	160	6	4	20	9.4	41	Pale brown paper
Wallaba (*Eperua falcata*) 1st sample	160	5	4	20	10.0	35	Soft grayish-brown paper of good strength
Kakaralli (*Eschweilera laevifolia*)	160	5	4	20	10.8	45	Soft brown paper of moderate strength
Mora (*Dimorphandra mora*)	160	5	4	20	10.0	48	Strong, pale brown paper
Yaruru (*Aspidosperma excelsum*)	160	6	4	20	12.6	46	Weak, soft, rather dark brown paper
Itikibouroballi (?)	160	5	4	20	9.4	42	Bulky, pale brown paper of moderate strength
Trysil (*Pentaclethra filamentosa*)	160	5	4	20	8.6	37	Strong, grayish-brown paper
Marishiballi (?)	160	6	4	20	11.1	40	Rather soft, pale brown paper of fair strength
Kautaballi (*Licania venosa*)	160	6	4	20	11.4	44	Pale brown paper, soft, rather bulky, and of poor strength
Morabukea (?)	160	5	4	20	9.4	45	Pale brown paper of good strength but with some shive
Moraballi (*Peltogyne ?*)	160	6	4	20	12.7	40	Pale brown paper of fairly good strength
Wallaba (*Eperua falcata*) 2nd sample	160	5	4	20	14.6	44	Soft, opaque, rather bulky brown paper
British Honduras							
Quam (*Schizolobium sp.*)	160	6	4	20	11.0	47	Rather soft, light brown paper of fair quality
White moho (*Hibiscus sp.*)	160	6	4	20	12.7	46	Pale brown paper of good strength and quality
Polak (*Ochroma sp.*)							
(a) hard	160	6	4	20	13.2	45	Light brown paper of good strength
(b) soft	160	7	4	30	17.0	43	Bleached pulp produced hard, tough white paper
Nigeria							
Abura (*Mitragyna macrophylla*)	160	6	4	20	11.6	36	Pale brown paper of fair strength and quality
Afara (*Terminalia superba*)	160	6	4	24	14.2	41	Fairly strong brown paper
Oro (*Irvingia barteri*)	170	9	4	24	15.6	37	Soft, rather weak, dark brown paper with some shive
Arere (*Triplochiton nigericum*)	160	6	4	24	13.6	44	Strong, light brown paper
Ogia (*Daniella ogea*) I	170	6	4	24	16.9	35	Light brown, opaque paper of good strength and quality
Ogia (*Daniella ogea*) II	170	6	4	24	14.5	39	Rather soft, dark brown opaque paper of good strength
Trinidad							
Acurel (*Trichilia oblanceolata*)	160	5	4	20	13.1	46	Rather bulky, pale brown, fairly soft opaque paper of good strength

Table I-b. Pulping Characteristics (*continued*)

Material and origin	*Soda cooks; conditions which gave a well-digested pulp* — *Maximum temperature, °C.*	*Time at maximum temperature, hr.*	*Strength of caustic soda solution, %*	*Caustic soda per 100 parts moisture-free wood, parts*	*Caustic soda consumed per 100 parts moisture-free wood, parts*	*Yield of unbleached moisture-free pulp on moisture-free wood, %*	*Paper furnished*
Hog plum (*Spondias mombin*)	160	5	4	20	14.7	47	Pale grayish-brown, tough, opaque paper of good strength
Yellow mangue (*Symphonia globulifera*)	160	5	4	20	12.2	47	Soft, opaque, bulky, brown paper of fairly good strength
Wild chataigne (*Pachira insignis*)	160	5	4	20	10.0	41	Tough, fairly bulky, opaque paper of good strength
Jigger (*Bravaisia floribunda*)	160	5	4	20	9.5	47	Pale brown, opaque paper of good strength
Bois mulatre (*Pentaclethra filamentosa*)	160	5	4	20	11.3	47	Pale brown, opaque paper of good strength
Mahoe (*Sterculia caribaea*)	160	5	4	20	9.7	51	Opaque, pale brown paper of good strength but with some shive
South Africa							
Eucalyptus saligna	150	6	4	25	12.5	58.3	Light, buff-colored sheets, slightly harsh texture, weak
Tanganyika							
Brachystegia sp. I	160	6	4	25	14.5	50	Light brown, soft, bulky sheets, some shive, weak
Brachystegia sp. II	160	6	4	25	15.3	45	Light brown, bulky sheets, fair amount of shive, very weak

and as far south as Northern Rhodesia and Portuguese East Africa. According to Davy and Hutchinson (*8*), two species are found in Kenya, one in Uganda, sixteen in Tanganyika, nine in Nyasaland, seven in Portuguese East Africa, seventeen in Rhodesia, ten in Angola, eighteen in the Katanga Province of the Belgian Congo, and six in Upper Guinea. In some areas *Brachystegia* grows in sufficient stands to warrant a thorough investigation as a papermaking material. Many of the species are slow growing, but others are reported to grow fairly quickly.

In 1948, the ultimate fibers from five species of *Brachystegia* were examined microscopically. The characteristics of the fibers were found to vary considerably among the species from thin-walled cells with wide lumen to those with thick walls and narrow lumen;

Table II. Beating Effect

Eucalyptus saligna Soda Pulp (Pulp N112A)

Beating time, min.	0	15	45	60	120	240
Revolutions	...	4500	13,500	18,000	36,000	72,000
Burst factor, g./sq. cm.	14.19	37.70	45.29	54.93	61.67	67.45
Breaking length, m.	3388	6822	8422	8736	10,210	11,290
Stretch, %	1.59	2.58	3.11	3.31	3.78	4.20
Tear factor, g.	47.55	92.26	111.7	98.88	107.2	93.99
Drainage time at 20° C., sec.	4.7	4.85	5.0	5.5	8.05	26.58

Medium Strength Commercial Kraft Pulp

Beating time, min.	0	30	60	120
Revolutions	...	9000	18,000	36,000
Burst factor, g./sq. cm.	21.5	75.2	80.9	83.2
Breaking length, m.	2960	8930	10,210	10,800
Stretch, %	2.1	3.1	3.4	3.2
Tear factor, g.	252	250	242	235
Drainage time, sec.	3.7 at 18.8°C.	4.0 at 21.3°C.	5.1 at 22.5°C.	8.8 at 18.9°C.

Brachystegia I Soda Pulp (Pulp N131)

Beating time, min.	0	30	60	120	240
Revolutions	...	9000	18,000	36,000	72,000
Burst factor, g./sq. cm.	12.3	18.5	21.0	21.8	28.0
Breaking length, m.	2798	3638	4053	4078	4701
Stretch, %	1.4	1.9	2.4	2.8	3.3
Tear factor, g.	38.7	41.0	42.1	41.2	44.0
Drainage time at 20°C., sec.	4.5	5.1	5.3	6.2	6.3

Brachystegia II Soda Pulp (Pulp N132)

Burst factor, g./sq. cm.	8.5	19.8	22.2	25.7	28.4
Breaking length, m.	2028	3597	3837	4645	4901
Stretch, %	1.0	2.3	2.3	2.9	3.1
Tear factor, g.	34.8	39.2	43.3	46.2	48.7
Drainage time at 20°C., sec.	4.6	4.8	5.0	6.2	6.0

generally, they had tapering ends. The average length of the fibers varied from 0.98 to 1.31 mm., and the diameter from 17 to 22 mμ.

An investigation of two species of *Brachystegia* from Tanganyika Territory is now being undertaken and, although incomplete, is sufficiently advanced to yield interesting information (*9*). Since the exact species of the two samples has not yet been determined, they are designated as *Brachystegia* I and II, and in order to save repetition, the results for the two samples will be given in that order.

The apparent density of the woods at 10.5 and 10.3% moisture, respectively, was 56.2 and 56.5 pounds per cubic foot. A chemical examination of the samples yielded the following results (expressed on the moisture-free material).

	Brachystegia I, %	*Brachystegia II*, %
Resin	0.5	3.5
Alkali solubility	12.3	21.4
Cellulose	58.8	51.4

It was considered that the resin content of both samples was satisfactorily low, but the high alkali solubility and the low cellulose content of *Brachystegia* II were thought undesirable features, from the papermaking point of view. The average lengths of the ultimate fibers were 1.2 and 1.0 mm. Under the microscope, the ultimates of both samples were very similar and appeared as cylindrical thin-walled cells with rather blunt ends; the fairly wide lumen continued almost to the end of the cells. An appreciable amount of broken fibers and parenchymatous tissue was observed.

As was expected from the chemical analysis, both samples were found to require moderately severe conditions of cook by the soda process in order to produce a well disintegrated pulp. Yields calculated on the moisture-free wood were 50 and 45%.

Evaluation of the pulp showed the breaking length, burst factor, and tear factor to be low for both samples; the pulp from *Brachystegia* I was considered to be weak in character and that from *Brachystegia* II to be very weak. The pulp characteristics of *Brachystegia* I were of the same order but rather weaker than the pulp from *Eucalyptus saligna*. Neither of the pulps was easily bleached.

The pulps from both samples of *Brachystegia* were similar in their poor response to beating, and only small increases in the breaking length, burst factor, and tear factor were observed even after 4 hours' beating. Another feature of the beaten pulps was a significant increase in the number of broken fibers observed under the microscope. When this paper was written, the examination of the cellulose was not completed, but the results to hand showed the pulps to contain not more than 50% alpha-cellulose and a high beta-cellulose content.

It has not been possible to deal with each timber in detail, and two tables have, therefore, been prepared which amplify the information given in the paper.

I believe it is reasonable to say that, although we have examined only a relatively small number of the colonial hardwoods available, there are undoubtedly a number which show considerable promise for the production of certain grades of paper. However, we have still to find a solution to the problem of the economic utilization of the material available. In addition to the factors to which reference has already been made, the heterogeneous nature of the trees in many of the forests has been a serious obstacle to any plan for development. In this connection, the methods for the pulping of mixed hardwoods which has been developed by French workers are worthy of very serious consideration.

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Viscose-Rayon Pulps from Chilean Hardwoods—Coigue, Tepa, and Ulmo

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A study was made of the possibility of producing pulp of viscose rayon grade from three Chilean hardwoods—coigue, tepa, and ulmo. Unbleached pulps were made from the three woods by (1) the neutral sulphite semichemical process with and without steam prehydrolysis, (2) a water prehydrolysis-sulphate process, and (3) the sulphite process. These pulps were purified by means of the conventional sequence of chlorination, alkaline extraction, oxidation, and acidic extraction. Yields of purified pulps, which contained from 2 to 7.5% of pentosans, ranged from 38 to 45% of the woods. Results of filtrability tests of viscose solutions from two of the pulps, of spinning trials on four of the pulps, and the general similarity of all of the pulps in chemical composition indicated that pulps acceptable for continuous-thread viscose rayon can be produced from the three woods by any of the processes investigated.

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The Forest Products Laboratory, in cooperation

with the Chilean Development Corp., has investigated the possibility of producing pulps from three Chilean hardwoods, coigue (*Nothofagus dombeyi*), tepa (*Laurelia serrata*), and ulmo (*Eucryphia cordifolia*) that would be acceptable for continuous-thread textile rayon.

Analytical values typical of commercial pulps used for this grade of rayon were obtained from rayon producers. These values were:

Alpha-cellulose, %	91.81
Beta-cellulose, %	4.26
Gamma-cellulose, %	4.33
Solubility in 7.14% sodium hydroxide solution, %	13.9
Dispersed viscosity (pulp at 0.5% concentration in cupriethylenediamine), cp.	11.6
Ash, %	0.09
Iron, p.p.m.	10
Copper, p.p.m.	3
Manganese, p.p.m.	0.5

Several pulping processes were applied to the three woods in order to determine the effect the pulping treatment had on the yield and quality of the purified pulp. All the purified pulps were evaluated by conventional tests and, in certain instances, by filtrability tests of viscose solutions and by spinning trials.

USE OF HARDWOODS FOR VISCOSE PULPS

The problem of producing a pulp from which a commercial, filtrable, viscose solution can be made is common to all cellulosic source materials used for this purpose. As mentioned in a recent interpretive review on cellulose and wood pulp research (*5*), the literature reveals much work directed toward identification of those characteristics of pulps which relate to unsatisfactory filtrability. These studies have dealt with the molecular properties of cellulose, the cell and so-called chemical composition of wood pulps, and the structure of the cells. The hypothesis that high-polymer fractions must be of abnormal composition (cross-bonded) to cause poor filtrability has also been proposed (*1*). Another hypothesis has been advanced concerning an interaction of hemicelluloses under the conditions of sulphate pulping. It is based on the assumption that, upon the rupture of lignin-hemicellulose bonds, the released hemicelluloses cross-link and form stable anhydro hemicelluloses that may have an adverse effect on the filtrability of a viscose solution (*14*).

In another investigation, insoluble residues of viscose solutions were found to be higher in methoxyl content than the original pulps. This was interpreted as indicative of the presence of nonglucosidic groups in the cellulose chains (*10*). Another has concluded that the "resin" component of pulp has a direct and favorable effect on the xanthation reaction and that, consequently, if too little resin is present, poor filtrability will result (*27*).

Although a rational system for predicting the filtrability of viscose obtainable from a pulp has not appeared in the literature, an empirical staining technique using Malachite green has been developed for this purpose (*35*). Its originator was able to classify pulps into five groups which would give viscose solutions ranging from nonfiltrable to readily filtrable.

The manufacture of viscose rayon from hardwood involves two problems peculiar to hardwoods. One is the high content of pentosan hemicellulose that must be removed; the other results from the short fibers and tracheids and the amount of parenchyma cells. Possibly neither of these is related to filtrability.

Because of the short fibers and tracheids and the high content of parenchyma cells, sheets of purified hardwood pulp are especially weak when in contact with a strong solution of sodium hydroxide. Difficulties encountered in industrial use because of this low strength include the breaking away of fibers from the sheets while they are steeping, the rupture of sheets while being pressed, and breakage of sheets as they are removed from the press.

The beating of purified pulp has been proposed as a means of increasing sheet strength sufficiently for conventional viscose preparation (*22*). The authors have been informed by a European manufacturer of hardwood viscose pulp that sufficient strength can be obtained by compressing the sheet in calendering to a density of approximately 1 gram per cc. Slurry steeping, characteristic of the continuous process for preparing viscose, avoids the problem of low sheet strength. This technique was considered of considerable importance in the development of purified hardwood pulp in Germany (*28*), and its use has also been reported in the United States (*4*).

It has been concluded that the parenchyma fraction of European beech sulphite pulp of viscose grade (about 15%) has no harmful chemical effects (*9*). A screen fraction containing about 80% of parenchyma cells underwent xanthation more rapidly than did the remaining fraction of the pulp which contained mostly fibers and tracheids. Any filtration difficulties were said to arise from the coarser of the two fractions. The finer fraction was about 4% lower in alpha-cellulose, and its degree of polymerization was 520 as compared with 850 for the coarser fraction. This variation of cells in degree of polymerization was observed in the case of a bleached sulphate eucalyptus pulp (*16*).

The facts that, in this country, a purified hardwood sulphite pulp has been used for a number of years and that a purified hardwood sulphate pulp has come into use recently are sufficient evidence that this type of pulp is chemically suitable and can be adapted to the mechanical requirements of the viscose process.

The extensive literature on the removal of hemicelluloses by pulping and subsequent purification and the associated effects, especially with reference to pentosans, has been summarized comparatively recently (*14–17, 31*) to provide a thorough correlative digest.

The desirability of a low proportion of pentosans in pulp for chemical conversion is widely emphasized. Hemicelluloses are converted to viscose as readily as is cellulose (*5*) and, when converted, are considered to have injurious effects on the properties of the regenerated fibers (*3*). Yet one "specification" would permit up to 4% of pentosans in viscose pulp, although with the qualifying recommendation that material with a degree of polymerization under 150 should be at a minimum (*12*).

It has been pointed out (*29*) that, in the German staple-fiber industry, it had been concluded from experiments that material of low degree of polymerization in pulps was harmful to the quality of the fiber, especially its strength when wet, and that material with a degree of polymerization of above 600 caused difficulties in operation associated with high solution viscosity. In a study (*2*) of the influence of polymolecularity of viscose rayons and of the corresponding cotton and wood pulps

on certain mechanical properties of the rayons, a high degree of correlation was found between the amounts of material of low degree of polymerization in the pulps and corresponding rayons, somewhat less between the ratio of weight to average degree of polymerization of the rayons and tenacity, and a fair degree between the amount of material of low degree of polymerization in the rayons and resistance to fatigue. It was concluded that the ratio of weight to average degree of polymerization and the amount of material of low degree of polymerization influence fatigue resistance of rayon to about the same degree. It was further suggested as fairly probable that most of the material low in degree of polymerization is removed from the pulp during the conventional steeping treatment and that the material low in degree of polymerization is produced during aging of the alkali cellulose. If this is true and from the correlations cited, it would follow that the amount of material of low degree of polymerization should be kept as low as possible and that the duration of aging of the alkali cellulose should be as short as possible.

Chain-length distribution curves showing the changes occurring in the cellulose during the production of sulphite viscose pulp and tire cord from pine grown in the southern states resulted in the theory that wood cellulose is comprised of only two fractions—namely, gamma (hemicelluloses) and alpha—and that the beta-cellulose of a wood pulp is not a hemicellulose of wood, but rather a result of degradation of the alpha fraction during pulping and purification (*18*). Unpublished data of the present authors appear to support this theory. Conventional beta- and gamma-cellulose values were obtained for holocellulose isolated from southern pinewood and from southern pine pulp prepared by a prehydrolysis-sulphate process. The beta values, based on the wood, increased from 0.5% for the wood to about 2% for the purified pulp. The gamma values decreased from 19% for the wood to 0.9% for the purified pulp.

Available data indicate that beta-cellulose and hemicelluloses are relatively low in molecular weight. The degree of polymerization values reported for beta-cellulose range from 10 to 150 (*11*, *30*). The fractions of European beech and spruce pulps extracted by an 8% solution of sodium hydroxide and then purified were found to have degree of polymerization values of 150 and 160 (*7*). These purified fractions were considered to be xylan and mannan. A crystalline xylan from American paper birch had a degree of polymerization value of 35 (*36*).

It is of interest to summarize the values for southern pine sulphite pulp which have been reported for viscose rayon of tire-cord grade. Proportions of alpha-, beta-, and gamma-celluloses and pentosans were, respectively, 95.00, 2.50, 2.50, and 1.98% (*19*). It appears from a chain-length distribution curve for this kind of pulp (*18*) that the fraction with a degree of polymerization value of 150 or less amounted to only about 4% and the fraction with a value of 500 or less, about 7%. If this interpretation is correct, it appears that the gamma and pentosan values are actually related to the same fraction unless it is assumed that the pentosans were all in the alpha-cellulose, which is doubtful for pulp made from softwoods. It has been suggested that gamma-cellulose is a mixture of pentosans and a constituent which absorbs chlorine (*25*).

When pulping is done under acidic conditions, the removal of hemicelluloses is not generally a problem, even in the case of hardwoods (*23*), and it might also be inferred, from a lack of evidence to the contrary, that filtrability is not a problem. It is well known, however, that both the removal of hemicelluloses and filtrability become problems when nearly neutral or definitely alkaline conditions are used for pulping. For an unbleached pulp having a high proportion of hemicelluloses, the preferred hot alkaline process is not adequate and the required cold process is not generally attractive economically. These two processes have been reviewed comprehensively in recent years (*15*, *16*).

The possibility of producing viscose pulps by an alkaline pulping process has been studied because it is suitable for any kind of wood (*8*, *20*). Prehydrolysis was developed as an adjunct for the removal of hemicelluloses (*24*, *26*). A possibly unforeseen but important result of the prehydrolysis-alkaline pulping sequence (specifically, prehydrolysis-sulphate) is the high quality of viscose rayon obtainable from this kind of pulp (*32*). An additional benefit attributed to prehydrolysis is an improvement in the behavior ("reactivity") of sulphate pulp in conversion to viscose yarn (*28*, *34*). Although a pine sulphate pulp, prepared by the cold alkaline extraction of bleached pulp, was used for a time in Germany for the production of viscose rayon tire cord, the prehydrolysis-sulphate type was preferred when it became available (*6*). The only information generally available on the commercial production and use of sulphate viscose pulps deals with German practice (*6*, *13*, *28*, *34*).

By applying a prehydrolysis-sulphate process and a conventional three-stage bleaching treatment to Australian eucalyptus, purified pulps were obtained which contained less than 2% of pentosans and up to 95.5% of alpha-cellulose (*17*).

The possibilities of producing a viscose grade of pulp by acidic hydrolysis of sulphate pulp prepared from sugar maple have been investigated (*31*), but the process does not appear to be economically feasible. An acidic treatment of pulp that utilizes the acid formed in a chlorination stage has been patented as a procedure in the purification of pulp for viscose (*21*). The preferred temperature is 40°C., and the maximum is 100°C. for a period of from 10 to 200 minutes. It is said that this procedure removes pentosans, and that lowering of the viscosity can be controlled more closely and with less harm to the alpha fraction than when oxidation is used for this purpose.

The same principle is found in a patented procedure for the production of bamboo pulp; the treatment in this instance consists of heating for 1 hour in the temperature range of 90 to 150°C. and a pH of 2. The proportion of alpha-cellulose was high in pulps made by this procedure (*33*).

WOODS USED IN THE PRESENT STUDY

Results of the tests applied to the samples of Chilean coigue, tepa, and ulmo used in the present study are given in Table I. TAPPI standards were used for the woods and pulps.

The coigue and tepa were of medium density and, in

that respect, were comparable with North American hardwoods, such as American elm, water tupelo, and sweetgum. The ulmo was much higher in density than the coigue and tepa, being comparable with the North American maples, birches, and some of the oaks.

In chemical composition, the three woods were typical of hardwoods in general. The alpha-cellulose contents, however, were at the relatively high level of approximately 48%, and the pentosan contents of the tepa and ulmo were in the low range. Although the pentosan content of the tepa was only 13.7%, an earlier sample contained 17.7%. The amount of ether-extractable material in the three woods was in the low range for hardwoods, but the coigue contained twice as much as either the tepa or ulmo, a difference that was reflected in the purified pulps.

PREPARATION OF THE UNBLEACHED PULPS

The processes used to make unbleached pulps from each of the three hardwoods were (1) neutral sulphite semichemical, with and without prehydrolysis, (2) prehydrolysis-sulphate, and (3) the acid sulphite. Stainless-steel, steam-jacketed, tumbling digesters were used. Pulping conditions are given in Table II.

Semichemical Pulping

Previous experience had indicated that the optimum lignin content for semichemical pulps to be bleached was about 10%. Thus, conditions were established in the preliminary neutral sulphite semichemical digestions to produce semichemical pulps of approximately this lignin content both with and without a steam prehydrolysis of the chips. As previously mentioned, the purpose of the prehydrolysis step is to remove the hemicelluloses, which in hardwoods are chiefly pentosans.

Table I. Physical Characteristics and Chemical Constituents of the Chilean Hardwoods, Coigue, Tepa, and Ulmo

Determination	*Kind of wood* — *Coigue* (Nathofagus dombeyi)	*Tepa* (Laurelia serrata)	*Ulmo* (Eucryphia cordifolia)
Physical characteristics[a]			
Specific gravity[b]	0.465	0.418	0.548
Density,[b] lb./cu. ft.	29.0	26.1	34.2
Proportion of incipient decay to total wood, %	3.65	10.83	2.24
Proportion of advanced decay to total wood, %	3.59	0.0	0.11
Average diameter inside of bark, in.	20.3	20.8	22.0
Average age, years	117	225	243
Average rate of growth, rings per inch	11.5	21.6	22.1
Chemical constituents[c]			
Lignin, %	23.2	28.2	26.2
Holocellulose, %	70.4	71.3	76.5
Alpha-cellulose,[d] %	47.6	48.0	48.6
Pentosans (total), %	17.3	13.7	14.9
Ash, %	0.3	0.8	0.5
Alcohol-benzene extractives, %	6.1	1.4	1.8
Ethyl ether extractives, %	0.6	0.3	0.3
Hot water extractives, %	6.6	2.1	3.4
Sodium hydroxide extractives,[e] %	18.2	9.7	16.5

[a] Average values obtained on transverse sections of all logs used in the experiments.
[b] Calculated on the basis of weight of moisture-free wood and volume of green wood.
[c] Determined on representative samples of chips used in pulping experiments.
[d] Determined on holocellulose.
[e] The concentration of sodium hydroxide in water solution was 1% by weight.

The three woods responded differently to semichemical pulping. The ulmo was the most responsive, requiring the least chemical and the shortest time. The coigue was somewhat less responsive, as shown by the higher chemical consumption and the longer pulping time required. The tepa was considerably more resistant than the other two and required a very large amount of chemical and, proportionately, a much longer equivalent cooking time. A digestion temperature of 180°C. was required in order to complete pulping in a reasonable time instead of the 170°C. needed for the others.

The steam prehydrolysis of the chips significantly decreased the time required for digestion but had essentially no effect on the amount of chemical required. It had, however, the effect of lowering the yield of unbleached pulp, because of the removal of hemicelluloses.

Only the prehydrolysis-semichemical pulp made from ulmo was purified because it was believed the results obtained on coigue and tepa afforded sufficient comparison between semichemical pulps made with and without prehydrolysis.

Sulphite Pulping

An ammonia-base sulphite liquor was used for pulping coigue and tepa because previous experience had shown those species to be incompletely pulped with conventional calcium-base liquor. Use of the ammonia-base was also expected to result in lower amounts of mineral matter and ether extractives in the pulps. Previous experience had also indicated that tepa is incompletely pulped with normal amounts of chemical, so a higher bisulphite content was used in the liquor for pulping that wood than for the coigue.

The coigue was pulped quite satisfactorily under the conditions used. A calcium-base sulphite liquor was found satisfactory for pulping ulmo under the conditions given in Table II.

Prehydrolysis-Sulphate Pulping

The results indicate that the three hardwoods can be pulped readily with the prehydrolysis-sulphate process. Acids generated during prehydrolysis lowered the pH value to 4. Although the conventional sulphate process was not applied to the woods, it can be said from experience with other hardwoods and with Chilean insignis pine that the prehydrolysis step lowers the amount of chemicals required to produce pulps of approximately the same lignin contents. In addition, the combination of prehydrolysis and sulphate pulping removes the hemicelluloses of hardwoods to an extent which permits the use of the hot extraction process with its attendant low requirement of sodium hydroxide. The descending order of ease of pulping by the prehydrolysis-sulphate process appears to be ulmo, coigue, and tepa, which was essentially the order for the semichemical and sulphite processes.

YIELD AND ANALYTICAL VALUES FOR THE UNBLEACHED PULPS

The yield values for the unbleached pulps given in Table III show that those for the semichemical pulps ranged from 54 to 67% and those for the chemical

Table II. Conditions Used in Preparing Unbleached Pulps from Coigue, Tepa, and Ulmo

Wood	Coigue				Tepa				Ulmo			
	N.S.S.C.[a]				N.S.S.C.[a]				N.S.S.C.[a]			
Process	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis	Sulphite, ammonia base	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis	Sulphite, ammonia base	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis	Sulphite, calcium base
Digestion	5238N	5266N	2953	5236I	5265N	5297N	2951	5237I	542Y	621Y	2950	5300I
Pretreatment												
Maximum pressure, p.s.i.	[b]	110[c]	[d]	...	[b]	110[c]	...	...	[b]	110[c]	...	...
Maximum temperature, °C.	[b]	...	160[d]	...	[b]	...	170[d]	...	[b]	...	170[d]	...
Elapsed time to maximum temperature, hr.:min.	...	0:45	1:15	...	...	0:45	1:30	...	...	0:45	1:30	...
Elapsed time at maximum temperature, hr.:min.	0:35	0:15	0:0	...	0:30	0:15	0:0	...	0:30	0:15	0:0	...
Total elapsed time, hr.:min.	0:35	1:00	1:15	...	0:30	1:00	1:30	...	0:30	1:00	1:30	...
Acidity at end, pH	...	...	3.97	...	...	...	4.19	...	...	...	3.97	...
Digestion												
Chemicals[e]												
Sodium sulphite, %	20.5	18.9	...	...	38.0	37.6	...	...	15.6	16.1	...	...
Sodium bicarbonate, %	11.0	7.4	...	...	15.4	15.8	...	...	6.4	7.0	...	...
Sodium hydroxide, %	...	...	14.1	...	...	...	15.5	...	...	...	14.1	...
Sodium sulphide, %	...	...	5.9	...	...	...	6.5	...	...	...	5.9	...
Sulphur dioxide												
Combined, g./100 ml.	...	...	...	1.10	...	...	...	1.44	...	...	...	1.19
Total, g./100 ml.	...	...	...	5.98	...	...	...	6.00	...	...	...	6.02
Maximum temperature, °C.	170	170	170	140	180	170	170	140	170	171	170	140
Elapsed time to maximum temperature, hr.:min.	0:10	0:15	1:30	4:30	0:30	0:25	1:30	4:30	0:10	0:05	1:30	4:30
Elapsed time at maximum temperature, hr.:min.	2:45	0:45	1:0	2:15	3:30	5:0	1:30	8:45	1:30	0:40	1:0	5:30
Total elapsed time,[f] hr.:min.	2:55	1:0	2:30	6:45	4:0	5:25	3:0	13:15	1:40	0:45	2:30	10:00

[a] Neutral sulphite semichemical. The partially digested chips were separated into a fibrous condition by means of the disk-attrition type of mill. After being screened, these pulps ranged in freeness from 600 to 770 ml Schopper-Riegler.
[b] Presteamed at atmospheric pressure.
[c] Steam hydrolysis.
[d] Water hydrolysis.
[e] Percentage values based on wood.
[f] For N.S.S.C. pulps, values do not include 1 hour used for impregnation of chips with cooking liquor at 120°C., following which the excess liquor was drained from the digester before cooking at a higher temperature.

Table III. Yield and Analytical Values for Unbleached Pulps Made from Coigue, Tepa, and Ulmo

Wood	Coigue				Tepa				Ulmo			
	N.S.S.C.[a]				N.S.S.C.[a]				N.S.S.C.[a]			
Kind of pulp	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis	Sulphite, ammonia base	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis	Sulphite, ammonia base	Without prehydrolysis	With prehydrolysis	Sulphate, prehydrolysis[b]	Sulphite, calcium base
Digestion	5238N	5266N	2953	5236I	5265N	5297N	2951	5237I	542Y	621Y	2950	5300I
Yield, %	66.6	50.4	39.3	47.0	54.4	54.4	41.8	41.2	71.2	58.3	43.4	43.5
Permanganate no.	38.0	...	...	15.8	...	...	11.3	4.0	...	...	9.6	8.4
Lignin, %	9.8	10.1	2.1	1.8	10.3	11.4	2.8	1.1	11.0	12.5	1.5	2.3
Total cellulose, %	82.3	87.9	98.0	96.6	83.7	84.6	97.0	99.0	79.2	84.0	94.7	98.1
Alpha-cellulose:												
Basis pulp, %	66.5	83.9	91.4	88.4	72.7	74.2	87.0	92.2	64.6	74.3	93.1	88.3
Basis wood,[c] %	44.4	42.3	35.9	41.5	39.5	40.4	36.4	38.0	46.1	43.3	40.4	38.4
Total pentosans, %	19.1	5.0	7.0	6.7	10.6	5.5	6.7	3.7	15.2	8.7	4.3	4.5
Solubility in ether, %	1.2	0.55	0.3	0.6	0.4	0.15	0.4	0.2	0.2	0.2	0.7	0.6
Viscosity,[d] cp.	...	...	70.1	35.4	...	...	16.1	10.7	...	...	53.7	20.5
Ash, %	1.4	0.8	0.4	0.4	1.0	1.2	1.2	0.3	1.1	0.8	0.4	0.6
Brightness	31.7	20.2	30.2	42.2	30.1	27.6	30.3	48.0	...	18.7	25.2	32.0

[a] Neutral sulphite semichemical.
[b] Yield following prehydrolysis was 81.5% and pentosan content was 9%.
[c] The alpha-cellulose contents of the three woods were approximately 48%.
[d] Pulp at 0.5% concentration in cupriethylenediamine.

pulps from 39 to 48%. A high yield is a characteristic of the conventional semichemical process, and the pulp obtained contains a considerable amount of lignin and hemicelluloses which have to be removed during the purification treatment.

With respect to yields of unbleached semichemical pulps made without prehydrolysis, the yield of tepa was very low in comparison with those for semichemical pulps of the same lignin content obtained from North American hardwoods, but the yields from coigue and ulmo were about the same. The yields of the unbleached pulps made with the prehydrolysis were lower than those of the corresponding pulps made without prehydrolysis because of differences in the amounts of hemicelluloses removed.

The alpha-cellulose contents of the three hardwoods were all close to 48% (Table I). Losses of alpha-cellulose in pulping can be determined by a comparison of that value with those for the unbleached pulps given in Table III. The comparison indicates that the semichemical process destroys less cellulose than the other two processes and that some destruction is to be expected by prehydrolysis. In general, the yields of alpha-cellulose reported are considered to be good.

There was a tendency toward more destruction of cellulose by the prehydrolysis-sulphate process than by the sulphite process. The markedly higher viscosity values of the unbleached sulphate pulps accords with the relative severity of hydrolysis of the two processes. Although the high amount of lignin in the semichemical pulps prevented complete dispersion for the determination of viscosity, they may have been higher in degree of polymerization than any of the others because of the very mild pulping treatment. The chemical pulps differed in viscosity over a range of about 11 to 70 cp.

A comparison of the total pentosans present in the woods and in the pulps made with the prehydrolysis step without added acid shows that even very mild hydrolytic treatment is highly effective in the removal of pentosan hemicelluloses from hardwoods.

Owing to the generally small amount of pentosans removed in the subsequent purification of these pulps, it is likely that a greater degree of removal of pentosans in the pulping would have been advantageous to the quality of the purified pulps. More recent experience with aspen shows that a pentosan content as low as 3% in the unbleached pulp results from a slightly increased period of hydrolysis at maximum temperature.

A comparison of ether-solubility values suggests that prehydrolysis was advantageous in the removal of ether extractives.

It is of interest to compare the coigue prehydrolysis-sulphate pulp with the Australian eucalyptus (*Eucalyptus regnans*) previously referred to (*34*), because of the similarity of the two raw materials and the differences in the pulping treatments. In the Australian work, the water prehydrolysis was done without added acid, as in the present study, but a higher temperature and a longer time were used. In the sulphate pulping, the maximum temperature was lower but a little more chemical and a longer time were used. For the eucalyptus pulp, the yield, alpha, and pentosan values were 32.5, 95.5, and 1.4% and, correspondingly, for the coigue pulp, 39.3, 94.3, and 7%. If one adjusts the yield value of the coigue pulp, in accordance with the lower pentosan content of the eucalyptus pulp and also allows for some additional loss, however, one may conclude reasonably that essentially the same character of viscose pulp and about the same yield are obtainable from Chilean coigue and Australian eucalyptus. On the same basis, it would be concluded that the yield of the very low pentosan type of pulp obtainable from the Chilean ulmo would be definitely higher than that from coigue.

PURIFICATION OF THE UNBLEACHED PULPS

The conditions used for the purification of the unbleached pulps are given in Table IV. A comparison of the total chlorine requirements of the pulps shows those of the semichemical pulps were much the highest, which accords with the high lignin contents of those pulps. Their chlorine requirements were in the range observed for neutral sulphite semichemical pulps of the same lignin contents made from North American hardwoods.

The high amount of hemicelluloses (chiefly pentosans) in the semichemical pulps prepared without the prehydrolysis step made it necessary to use the cold extraction process, following chlorination, in order to remove the required amount of hemicelluloses. For the coigue, the amount of alkali required in the cold extraction of the semichemical pulp was 13 times more than the amount required for the corresponding

Table IV. Conditions Used in the Purification of Pulps Made from Coigue, Tepa, and Ulmo[a]

Kind of wood	Kind of pulp	Digestion	Purification	Stage 1, chlorination, chlorine, %	Stage 2, alkaline extraction			Stage 3,[b] oxidation		
					Sodium hydroxide, %	Temperature, °C.	Elapsed time, hr.	Chlorine as sodium hypochlorite, %	Temperature, °C.	Elapsed time, hr.
Coigue	N.S.S.C.[c]	5238N	1268	15.0	47.0	25	1.0	1.0	30	5
	Prehydrolysis-N.S.S.C.	5266N	1331	12.0	3.6	80	0.75	1.0	32	4
	Prehydrolysis-sulphate	2953	1340	2.0	3.0	80	0.75	1.5	38	4
	Sulphite	5236I	1368	4.0	3.0	80	0.75	1.0	30	5
Tepa	N.S.S.C.[c]	5265N	1493	15.0	32.3	24	1.0	0.8	30	4
	Prehydrolysis-N.S.S.C.	5297N	1492	16.0	10.0	110	0.75	1.0	32	4
	Prehydrolysis-sulphate	2951	1370	2.7	3.0	80	1.0	1.5	38	5.25
	Sulphite	5237I	1319	1.5	5.0	90	1.0	0.5	30	4
Ulmo	Prehydrolysis-N.S.S.C.[c]	621Y	1518	18.0	10.0	91	0.75	1.0	33	5
	Prehydrolysis-sulphate	2950	1333	2.0	3.0	81	0.75	1.5	39	5
	Sulphite	5300I	1499	2.5	3.0	80	0.75	0.8	30	4

[a] Percentage values for chemicals used are based on weight of unbleached pulp. Consistence or density values in per cent were: 2 for chlorination, 10 for alkaline extraction and oxidation, and 4 for acid extraction. Temperature during chlorination was 25°C. During oxidation with sodium hypochlorite, the pH was maintained at 8.5 to 9.

[b] Stage 4 was an acid extraction treatment. The treatment applied in purifications 1268 and 1331 comprised first a steep in hydrochloric acid solution at pH 2 and a temperature of 25°C. for 1 hour, then a thorough washing and then a steep in hydrofluoric acid solution at pH 1.2 and 25°C. for 1 hour. The pulp was then washed, neutralized with ammonium hydroxide, and washed again, all with solids-free water. The acid extraction treatment used for all other pulps comprised a steep in 1% oxalic acid solution at 25°C. for 1 hour.

[c] Neutral sulphite semichemical.

prehydrolysis-semichemical pulp, and similarly, for the tepa semichemical pulp, it was a little over three times. Although the hot alkaline extraction process was adequate for all the other pulps, the tepa and ulmo semichemical pulps required from two to three times more alkali than did the others in this group, which were quite similar in their requirements.

A final steeping in acidic solution was applied to the pulps as described in Table IV to lower the iron content. These treatments had only a slight effect on the dispersed viscosity. The iron was a result of contamination and did not result from the woods from which the pulps were made.

As previously mentioned, the unbleached pulps differed a great deal in viscosity. Because of this, they were not processed to a common minimum viscosity. However, the decreases effected during purification ranged from 4 to 53 cp.

YIELD AND TEST VALUES FOR THE PURIFIED PULPS

Yield and analytical values for the purified pulps are given in Table V.

Although the yields of the purified pulps are not directly comparable because of the differences in alpha- and beta-cellulose contents, it is believed even the lowest would compare favorably with the yields obtained in present commercial production. It is understood that the potential yield of viscose rayon yarn is sometimes estimated to be the sum of the amount of alpha-cellulose plus one half the amount of beta-cellulose in the pulp. The following tabulation arranges the pulps in descending order of yield on that basis.

Kind of pulp	*Estimated yield of viscose rayon yarn, percentage based on wood*[a]
Coigue neutral sulphite semichemical	44
Coigue prehydrolysis-neutral sulphite semichemical	42
Coigue sulphite	42
Ulmo prehydrolysis-sulphate	41
Ulmo prehydrolysis-neutral sulphite semichemical	41
Tepa neutral sulphite semichemical	41
Tepa prehydrolysis-neutral sulphite semichemical	40
Ulmo sulphite	39
Tepa prehydrolysis-sulphate	39
Coigue prehydrolysis-sulphate	37
Tepa sulphite	36

[a] Values adjusted to nearest whole number. Order was not affected by so doing.

The foregoing tabulation indicates that the highest yield of yarn from the three hardwoods can be obtained by means of the semichemical process, the next highest by the prehydrolysis-sulphate process, with the sulphite process third in order. The yield value given for the coigue prehydrolysis-sulphate pulp is believed to be somewhat low because of the conditions used in pulping and purification or experimental error. The results also indicate that slightly higher yields may be expected from coigue and ulmo than from tepa.

In general, the chemical composition of the purified pulps met the requirements which had been selected on the basis of analytical values typical of commercial sulphite viscose pulps and known to be acceptable for continuous-thread viscose rayon. The tepa sulphite pulp was definitely high in sodium hydroxide solubility and the ulmo prehydrolysis-semichemical

Table V. Yield and Analytical Values for the Purified Pulps Made from Coigue, Tepa, and Ulmo

Wood	*Coigue*				*Tepa*				*Ulmo*		
	N.S.S.C.[a]				*N.S.S.C.*[a]				*N.S.S.C.*,[a]		
Kind of pulp	*Without prehydrolysis*	*With prehydrolysis*	*Sulphate, prehydrolysis*	*Sulphite, ammonia base*	*Without prehydrolysis*	*With prehydrolysis*	*Sulphate, prehydrolysis*	*Sulphite, ammonia base*	*with prehydrolysis*	*Sulphate, prehydrolysis*	*Sulphite, calcium base*
Digestion	5238N	5266N	2953	5236I	5265N	5297N	2951	5237I	621Y	2950	5300I
Purification	1268	1331	1340	1368	1493	1492	1370	1319	1518	1333	1499
Yield											
Basis pulp, %	68.2	86.7	97.6	93.4	79.8	79.6	97.0	90.7	75.2	94.6	94.7
Basis wood, %	45.5	43.6	38.4	43.9	43.4	43.3	40.5	37.4	43.8	41.1	41.2
Alpha-cellulose[b]											
Basis pulp, %	94.7[b]	94.6	94.3	92.5	92.7	91.7	92.5	92.3	92.7	96.3	92.5
Basis wood, %	43.0	41.4	36.2	40.6	40.2	39.7	37.5	34.3	40.7	39.6	38.2
Beta-cellulose, %	4.1	3.3	5.8	5.3	4.0	2.5	6.5	7.0	4.7	3.8	3.7
Gamma-cellulose, %	1.2	2.1	0.0	2.2	3.1	5.7	1.0	0.7	2.3	0.0	3.7
Pentosans, %	7.4[b]	3.6	6.7	4.5	7.3	6.3	5.6	2.1	8.9	4.4	3.6
Solubility in											
Ether, %	0.25	0.4	0.3	0.4	0.1	0.15	0.0	0.1	0.2	0.2	0.2
Sodium hydroxide, %	8.6	9.7	11.4	9.2	13.2	10.2	10.3	16.8	14.9	8.8	15.5
Viscosity,[d] cp.	15.9	17.2	12.2	21.0	9.9	13.4	6.3	6.7	22.8	6.6	14.9
Ash, %	0.07	0.07	0.08	0.11	0.26	0.14	0.2	0.13	0.09	0.07	0.13
Iron, p.p.m.	27.0[c]	61.0	33.0	29.0	. .	46.0	33.0	20.0	. .	33.0	. .
Brightness, %	87.0	84.3	82.4	82.1	86.0	85.6	81.0	85.0	86.6	82.6	84.6

[a] Neutral sulphite semichemical.
[b] The alpha-cellulose contained 8.2% pentosans which is equivalent to 7.7% based on the purified pulp. The rayon yarn made from the pulp contained 6.6% pentosans.
[c] The unbleached pulp contained 110 p.p.m. of iron.
[d] Pulp at 0.5% concentration in cuprietylenediamine.

and sulphite pulps were at the upper limit of acceptability in this respect.

There was indication of a trend toward higher disperse viscosity in the semichemical pulps than in the other two kinds. There was also a trend toward higher viscosity in the sulphite pulps than in prehydrolysis-sulphate pulps, if the greater degree of pulping used in the preparation of the tepa sulphite pulp is discounted.

With the exception of the tepa sulphite pulp, all the experimental pulps were high in pentosans in comparison with values typical of commercial softwood sulphite viscose rayon pulps. Data obtained in the present study and earlier but unpublished data indicate that, in a softwood viscose pulp, only a small proportion of the total pentosans are in the alpha-cellulose but that, in a purified hardwood pulp, from 75 to 100% of the pentosans are in the alpha-cellulose and, furthermore, they appear in the yarn. An analysis for pentosans made on yarn from the coigue semichemical pulp gave a value of 6.6%.

It would be desirable to have available a comparison of the properties of yarns and films made from a series of hardwood prehydrolysis-sulphate pulps varying as widely as feasible in pentosan content.

Despite the final steeping in acidic solution, the iron content of all the purified pulps was very high. This indicates that the residual iron was present as discrete particles. Since the experiments described here were made, a comprehensive survey of sources of contamination by iron in the small-scale and pilot plant bleaching operations has resulted in the practical elimination of this difficulty.

The pulps differed in viscosity over a range of about 6 to 23 cp.

Screen-fractionation data for three of the coigue pulps are given in Table VI. These data show that about 60% by weight of coigue pulp was retained on an 80-mesh screen and about 20% passsed through a 150-mesh screen under the conditions of fractionation used.

STRENGTH OF SHEETS WET WITH SODIUM HYDROXIDE

As previously mentioned, the low strength of sheets of hardwood dissolving pulps when wet with a strong sodium hydroxide solution has been said to be a source of difficulty in the conventional process for the manufacture of viscose rayon.

It was reported that sheets of purified coigue sulphite pulp split to some extent during the steeping treatment in connection with viscose filtrability tests. No failures of any sort, however, were reported for the sheets of the purified tepa prehydrolysis-sulphate pulp. This suggests the possibility of adequate strength in the sulphate type of pulp.

FILTRABILITY OF VISCOSE SOLUTIONS FROM EXPERIMENTAL PULPS

The filtrability of viscose solutions made from the tepa prehydrolysis-sulphate, the coigue sulphite, and certain commercial pulps was determined by an industrial viscose laboratory. In comparison with a European softwood sulphate pulp of viscose grade, the tepa sulphate pulp had the same dispersed viscosity, the alkali cellulose required less aging, the combined sulphur in the viscose was the same, the rate of ripening of the viscose was essentially the same, and the viscose was definitely superior in filtrability.

The coigue sulphite pulp had three times the dispersed viscosity of a sulphite viscose pulp prepared commercially from a North American hardwood, and twice that of a similar softwood, but its reaction rate during aging was not significantly slower. The combined sulphur in the viscose from coigue pulp was about the same as that in the softwood control pulp but less than that in the hardwood pulp. Its rate of ripening was similar to the softwood pulp but faster than that of the hardwood pulp, and its filtrability was almost as good as that of the hardwood and definitely better than that of the softwood sulphites.

SPINNING TRIALS

Viscose rayon yarn of continuous-thread grade was made by an industrial laboratory from 5-pound samples of the two coigue semichemical pulps and the coigue and ulmo prehydrolysis-sulphate pulps, which ranged from 3.6 to 7.4% in pentosans. It was reported that the experimental pulps reacted normally toward the viscose-making process and that the experimental yarns were of commercially acceptable quality.

ANALYTICAL METHODS

The solubility of the purified pulps in sodium hydroxide solution was determined according to Joint Army-Navy (U. S.) Specification, JAN-C-216, Cellulose, Wood Pulp (May 29, 1945).

Alpha-, beta-, and gamma-celluloses were determined by the gravimetric procedure given in Forest Products Laboratory Report No. R19.

The amounts of iron and copper were measured according to Forest Products Laboratory spectrophotometric procedures. In either instance a pulp

Table VI. Screen-Fractionation Data for Unbleached and Purified Pulps from Coigue

Pulp	*Purification*	*Fractions and amounts* — *Retained on 80-mesh screen, %*	*Retained between 80- and 115-mesh screens, %*	*Retained between 115- and 150-mesh screens, %*	*Retained between 150- and 200-mesh screens, %*	*Passing a 200-mesh screen (by difference), %*
Neutral sulphite semichemical, digestion 5238N:						
Unbleached	...	67.2	9.8	3.5	1.5	18.0
Purified	1268	66.7	14.5	4.9	2.0	11.9
Prehydrolysis-neutral sulphite semichemical, digestion 5266N:						
Unbleached	...	56.6	16.9	4.2	0.6	21.7
Purified	1331	64.4	16.1	3.1	1.6	14.8
Sulphite, digestion 5236I:						
Unbleached	...	60.6	17.6	3.5	2.7	15.6
Purified	1368	50.8	21.0	3.1	3.3	21.8

sample is put into solution by the oxidizing action of nitric, sulphuric, and perchloric acids. Orthophenanthroline is used to form the colored complex with iron and tetraethylenepentamine to form that with copper.

CONCLUSION

The results of the filtrability tests, the spinning trials, and the general similarity in chemical composition of all the experimental pulps warrant the conclusion that pulps, chemically satisfactory for continuous-thread rayon, can be made from Chilean coigue, tepa, and ulmo by: (1) the neutral sulphite semichemical process, with or without a prehydrolysis step, (2) the prehydrolysis-sulphate process, and (3) the sulphite process in conjunction with suitable but simple purification treatments. The study also indicates that pentosans closely associated with the alpha-cellulose of hardwoods may be less harmful to the quality of viscose products than the pentosans of softwoods.

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Development of Chemical and Semichemical Processes for Deciduous Trees with Special Consideration of Tropical Woods of Western Africa

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As a result of the third World Forestry Congress at Helsinki in 1949, Section 5 (Forest Industries) made the following suggestions which are of far-reaching importance for the development of a suitable supply of raw materials for the paper and board industry.

1. To conserve softwoods, hardwoods, and specially tropical woods, are to be used in larger quantities.
2. The development of semichemical processes and the production of semichemical pulps are to be expanded, thus conserving pulpwoods through the higher yields obtained.

These two proposals are closely related, since the hardwoods are particularly suitable for the production of unbleached and bleached semichemical pulps.

Since the tropical forests, which cover nearly 48% of the forest area of the world, are composed predominantly of hardwoods and since the rapid growth of these forests represents an annual production of pulpwood equal to more than half the total world production, the solution of the problem relating to the utilization of hardwoods by the paper industry is of very great importance. This problem was recognized many years ago but since, at that time, there was no shortage of softwoods, little use was made of the results of the research work which was available. In Europe, for example, the application was limited to the utilization of poplarwood in Italy and of beechwood for dissolving pulp in Germany.

During the years 1925 to 1930, an industrial laboratory of which the author was the director studied the problem of pulping *Fagus silvatica* and thereby demon-

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Table I. Defibration of Hardwoods Treated with the Semichemical Soda Process

Wood / Base, % / Meshes/sq. cm. / Gr.	Beech 3.15 19%	Beech 3.15 567%	Beech 3.15 9272%	Maple 3.74 19%	Maple 3.74 567%	Maple 3.74 9272%	Pine 3.74 19%	Pine 3.74 567%	Pine 3.74 9272%	Spruce 2.55 19%	Spruce 2.55 567%	Spruce 2.55 9272%
1	61.6	27.6	10.9	17.0	75.7	7.3	..	..	..	..	..	..
1.25	71.5	18.2	10.0	26.0	62.7	11.3	..	..	..	..	..	..
1.5	81.0	9.0	10.0	32.0	54.0	14.0	..	..	..	..	..	..
1.75	85.7	4.3	10.0	45.4	37.4	17.2	..	..	..	..	..	..
2	87.8	2.4	9.8	49.3	31.6	19.1	..	..	..	..	..	..
2.5	..	..	..	63.6	15.9	20.9	..	..	..	..	..	..
2.75	..	..	..	66.6	12.5	20.9	..	..	..	..	..	..
3	..	..	..	..	..	..	..	..	..	32.0	58.3	9.7
3.5	..	..	..	..	..	..	41.5	47.8	10.7	..	..	..
4	..	..	..	..	..	..	47.5	44.1	10.4	51.2	36.3	12.5
5	..	..	..	..	..	..	65.0	21.1	13.9	..	..	..
5.5	..	..	..	..	..	..	74.2	11.4	14.4	73.7	10.7	15.6
6	..	..	..	..	..	..	74.1	6.9	16.0	78.7	4.0	17.3
6.5	..	..	..	..	..	..	84.3	2.7	13.0	..	..	..
Yield, %		82.2			85.2			82.3			82.7	

strated the possibility of utilizing hardwoods through the manufacture of a bleached semichemical pulp.

Runkel demonstrated in 1930 that, through the use of a weak alkaline liquor, it was much easier to obtain a high yield of unattached fibers from hardwoods (beech, maple) than from softwoods (pine and spruce). The defibration of a partially delignified hardwood requires about one third of the power which is required for softwoods. Table I shows the results of cooking wood 8 hours at 100°C. with 10% sodium hydroxide (on basis of dry wood), defibration in a rod mill, and passage through screens with 19 (fibers), 567 (shives), and 9272 (slime) meshes per sq. cm. The liquor concentrations are given.

Bleaching studies of these semichemical pulps showed that they required a much higher amount of chlorine. However, the process gave higher yields than those obtained previously and the pulps had very high strength values. Calculations showed that the higher cost of the bleaching agent was offset by the higher yields.

An analytical study of the chemical decomposition of wood in stages was also carried out. It was found that the high hemicelluloses content was responsible not only for the high yields but also for the increased strength properties of the hardwood pulps. In particular, it was observed that a certain pentosans content (measured by the furfural yield) was responsible for the improved sheet formation or binding of the fibers in the paper.

The above research, mode 25 or 30 years ago, becomes very important in this period of proposed utilazation of hardwoods. At the same time that these experiments were carried out, work was started in the United States along similar lines; special mention should be made of the work of Rue, Rawling, Wells, and Staidl who developed the so-called neutral sulphite method for producing semichemical pulp in a rod mill.

Since 1939, the author has been engaged in applying the results obtained on beechwood to tropical woods, particularly to those woods from Western Africa (Cameroons), Chile, Indonesia, Australia, and last, but not least, Bolivia. Because of the considerable knowledge regarding the occurrence of tropical woods, it is possible to determine their value from a technical as well as from an economical standpoint.

If I were asked for a summarized judgment, it would be as follows:

The application of the acid sulphite process is not suitable.

The application of the sulphate process is suitable for unbleached and bleached pulps.

The application of the soda process is not suitable for unbleached pulps but is suitable for bleached pulps.

The semichemical processes are very suitable for bleached pulps.

In the study of the hardwoods of the temperate zone (such as beech and poplar) and particularly of the tropical woods, results on their specific gravity and fiber length have been obtained which have been confirmed by various other workers. The following may be cited.

The spring- and summerwood of temperate zone woods have annual rings which contain a fibrous mate-

Table II. Morphological Nature of Fiber and Pulp Types

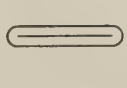
Wood Species	Extremely Hard: Diospyros	Extremely Hard: Guajacum	Hard: Lophira procera	Hard: Rhizophora mangle	Middle: Sarcocephalus	Middle: Ptero carpus	Soft: Terminalia	Soft: Canarium	Soft: Pycnanthus combo	Very Soft: Ceiba pentandra	Very Soft: Musanga smithii
Weight per unit of volume	1.32	1.27	1.12	1.04	0.80	0.73	0.59	0.50	0.49	0.29	0.21
Cross section in wood											
Cross section in paper											
Cementation	Very slight		Slight		Middle		Good			Very good	
Strength (unbeaten)	Very small		Small		Middle		Good			Very good	
Breaking length, m.	...	...	1579	1565	...	1806	2520	..	5758	5019	5122
Folding strength	...	...	...	...	...	2	2	..	199	132	465
Opacity	Opaque		Opaque		Somewhat transparent		Transparent			Very transparent	
Beating			Fibrillating		Partly fibrillating, Partly crushing		Partly fibrillating, partly crushing				

Table III. Chemical Pulp Types (Bleached)

Hemicelluloses, %	Ca. 3–10	11–15	16–25	Higher than 26
Strength	Small	Good	Very good	Smaller
Cementation	Slight	Strong	Very strong	Smaller
Beating capacity	Difficult	Easier	Very easy	Very easy
Opacity	High	Smaller	Transparent	Very transparent

rial that is heterogeneous from a chemical and a morphological viewpoint; chemically, it has a high lignin content; morphologically, there are thin-walled fibers in the springwood and thick-walled fibers in the summerwood. On the other hand, some of the tropical wood

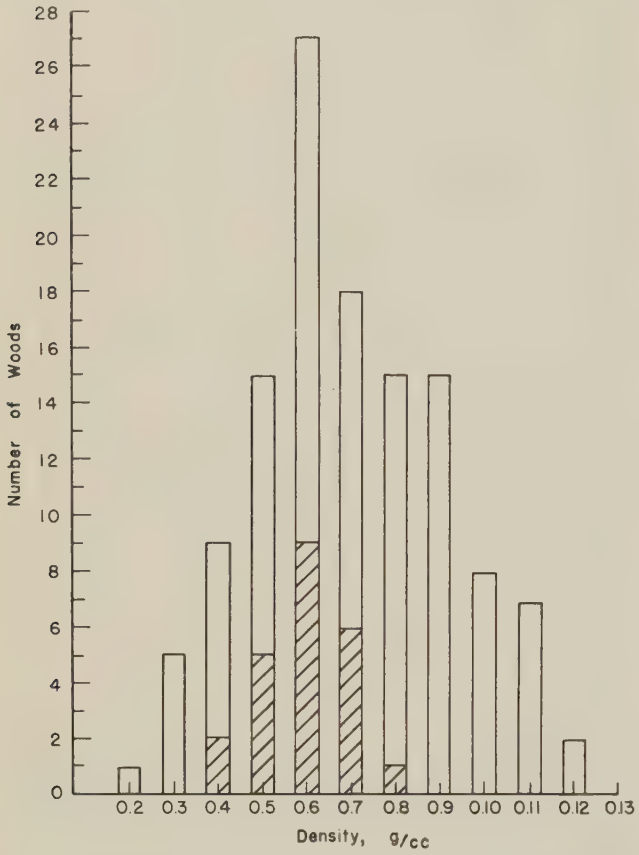


Fig. 1. Number of species of 122 woods from the Cameroons in comparison with 23 woods from Middle Europe in relation to their specific gravity (Trendelenburg). Open bars, woods from Cameroons (222); hatched bars, woods from Middle Europe (23)

species possess a very homogeneous structure, sometimes interrupted by so-called growth rings or a gradual change from sapwood to heartwood.

As compared with softwoods, hardwoods of all climate zones have considerably shorter fibers. Some tropical woods, such as *Rhizophora* and *Lophira* have fibers whose length is above the average (about 2 mm.) but others, like *Guajacum* (pockwood), *Tectone* (teakwood), and *Diospyros* (ebony) have extremely short fibers (from 0.5 to 1 mm.). It appears that those woods which are particularly rich in extractives have short fibers.

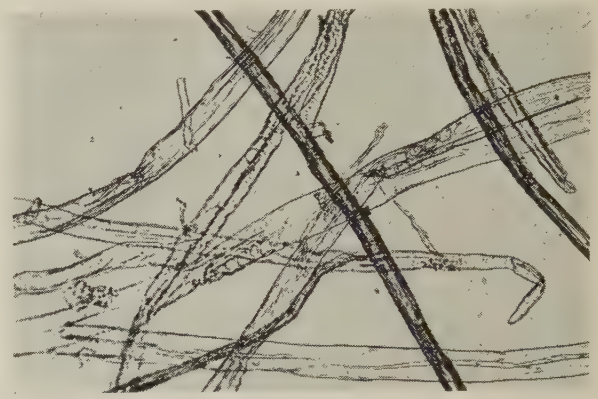


***Fig. 2. Springwood fibers (thin-walled) and summerwood fibers (thick-walled) in a pulp from* Picea excelsa**

Tropical woods have an extremely wide range of specific gravities (balsa, 0.075; quebracho and pock, 1.35 g. per cc.), whereas the specific gravity of hardwoods of the temperate zone range between 0.4 (poplar) and 0.8 (oak). In the tropical rain forest there are more heavy woods than light woods and their specific gravities are usually above those of the woods of the temperate zone.

The thickness of the fiber walls of tropical woods is also very different, ranging from 1 to 8 mu.

The number of wood species in the tropical zone is from 20 to 50 times the number in the temperate zone. Pure stands are scarce in tropical forests.

The chemical analysis of many tropical woods is often very difficult; this is particularly true of the lignin determination.

Table IV. Results of Pulping Various Woods from the Cameroons

		Sulphate[a]				Semichemical soda[c, d]	
		Unbleached		Bleached[b]			
Wood	*Sp. gr.*	*Breaking length, m.*	*Folding strength*	*Breaking length, m.*	*Folding strength*	*Breaking length, m.*	*Folding strength*
Diospyros spec.	1.32	..	..	..	..	..	..
Guajacum	1.27	..	..	..	..	..	..
Lophira procera	1.12	4,020	431	5,041	2	85,500	1,020
Rhizophora mangle	1.09	5,555	325	4,930	90	8,199	728
Sarcocephalus	0.80	4,852	89	4,312	79	..	..
Pterocarpus	0.73	4,538	18	4,300	2	..	..
Terminalia superba	0.59	5,270	39	5,780	83	..	..
Canarium	0.50	8,160	804	7,110	94	..	..
Pycnantus combo	0.49	6,603	619	5,590	138	..	..
Cebia pentandra	0.29	11,300	818	5,914	51	10,068	3,197
Musanga smithii	0.21	9,863	1788	10,200	1021	11,529	11,331

[a] Pulped at 170°C., beaten to 60° S.-R.
[b] Bleached with chlorine and sodium hypochlorite.
[c] Pulped at 100°C., beaten to 60° S.-R.
[d] Bleached with sodium chlorite.

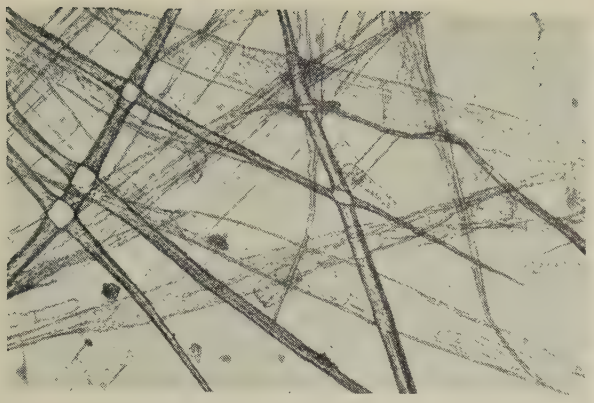


Fig. 3. Thin-walled fibers of Musanga smithii *(Western Africa) and thick-walled fibers of* Rhizophora mangle *(Western Africa) in a mixed (1:1) cook. 30×*

The sample for the chemical analysis of a tropical wood is to be selected with great care; consideration must be given to the variations in heartwood, sapwood, stem height, age, compression or tension wood, and the like.

These facts may be of great importance to the pulp and paper industry.

MIXED COOKS

Mixed cooks may consist of three different types.

Mixed cooks of a wood with botanically allied woods—e.g., woods of the same family or those of similar volume weight. These cooks present no difficulties if pulped with an alkaline or neutral sulphite semichemical process.

Mixed cooks of heterogeneous wood, particularly those with very different volume weight. Differences are observed in the velocity of the diffusion of the cooking liquor into the chips, which will cause variations in the disintegration of the chips. This difficulty can be avoided if the chip size is in inverse proportion to the volume weight or if the same number of chips (per unit weight) is taken for each wood species.

Mixed cooks of woods as obtained from the forest. Certain woods will present difficulties—e.g., those containing extractives or those having a low pore volume are difficult to disintegrate. Such woods should be separated from the mixture.

Mixed cooks of allied species are necessary because such species occur in the same forest—e.g., *Lauraceae* in the Yungas forests of Bolivia.

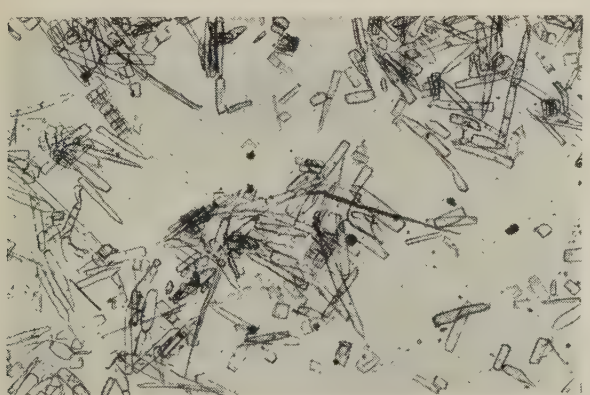


Fig. 4. Parenchymatic fractions of a pulp from Ochroma lagopus *(balsa; South America). These fractions give a very dense and waterproof paper. 20×*

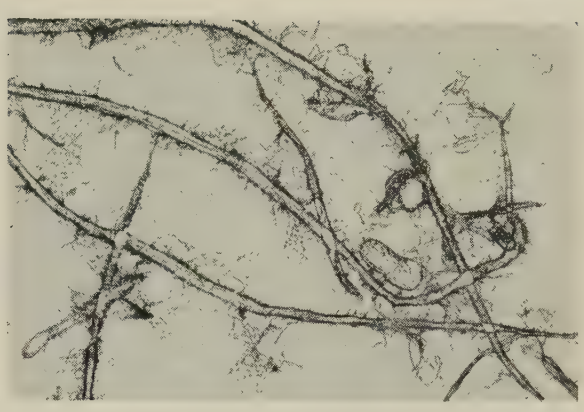


Fig. 5. Pulp fibers from Lophira procera *(bongossi, Western Africa) beaten to 71° S.-R. The fibers are not shortened but are surrounded by hairlike fibrils. 85×*

Some woods, like teak or ebony, will cause difficulty in a mixed cook because they cannot be bleached. Such woods must be removed before the others are pulped. Naturally, the pulping of only one wood species is preferable; in most cases this is not possible but, if possible, a certain selection should be made of the woods to be pulped at one time.

ADVANTAGES OF MIXED COOKS

The pulping of spruce and pine may be regarded as a mixed cook because of the differences between the spring- and summerwood. Various parts of the wood contain different lignin contents and also have cell walls with different thicknesses.

Influence of the Cell Wall Thickness. The properties of papers are strongly influenced by the cell wall thickness of the fibers. Fibers with thick walls furnish soft and opaque papers, whereas those with thin walls yield solid and transparent papers. The natural mixture of spring- and summerwood fibers can be imitated by artificial mixtures of light tropical woods (balsa, cetico, musanga) with heavy woods (eucalyptus, mangrove, bongossi). In this manner papers can be prepared which are similar to those which are manufactured from the softwoods of the temperate zone. Fibers which have extremely thick or extremely thin walls may be used for special papers (blotting paper from the thick-walled fibers; parchment or glassine papers from the thin-walled fibers).

A wood can be characterized chemically by its content of extractives, holocellulose, and lignin and morphologically (in addition to the fiber length) by the

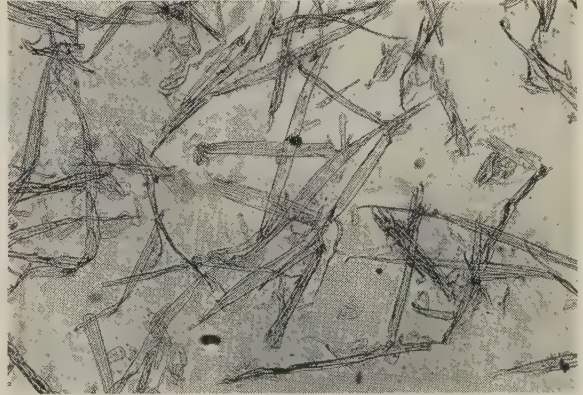


Fig. 6. Fibers of Musanga smithii *beaten to 32° S.-R. Even at this degree of beating, the fibers are often crushed and the sharp fiber ends are broken off*

thickness of the cell wall (which can be seen in a cross section). A paper has been formed from the parenchyma cells of balsa pulp which had a breaking length of 13,144 meters and 4740 double folds. This paper, formed from small rectangular cell walls (275 mu in length and 55 mu in width) rich in pentosans, demonstrated that the fiber length is not an important factor in the breaking length and the folding endurance. Figure 4 shows the parenchymatic fractions of balsa. Figures 5 and 6 show the fibrillation of an extremely thick fiber on beating (bongossi) and the crushing of an extremely thin fiber (musanga).

Influence of the Hemicelluloses. As discussed above, the hemicelluloses content of hardwood pulps is an important factor in their properties, such as beating time, strength, and opacity. Jayme has investigated the maximum strength properties of pulp from *Fagus silvatica* in relation to the hemicelluloses content of the bleached pulp. Maximum strength is obtained with a bleached pulp yield of about 50%. This means that this pulp has a hemicelluloses content of about 20%. Runkel has confirmed this observation by experiments on many woods—e.g., eucalyptus, musanga, and other woods with a wide variation in specific gravity. Thus, for most hardwoods, there appears to be a range of hemicelluloses content which is optimum for the over-all quality of the bleached pulp. Table III contains qualitative data relative to the behavior of bleached pulps.

Table IV gives the results of pulping west African woods by the sulphate process (170°) and by the soda semichemical process (100°); in each case the pulp was beaten to 60° Schopper-Riegler. The sulphate pulps were bleached with chlorine and sodium hypochlorite, whereas the semichemical pulps were bleached with sodium chlorite. Data are given for the breaking length and the folding endurance. Woods with a low specific gravity yield the best pulps but certain heavy woods, such as *Lophira procera* and *Licophora mangle* yield satisfactory pulps by the semichemical process and sodium chlorite bleaching.

Semichemical Pulping of Mixed Woods. The semichemical process is very well adapted to mixed cooking. The refiner has an equalizing effect upon the pulp and makes it more suitable for bleaching by the chlorine-hypochlorite process.

In addition to multistage bleaching with chlorine, sodium hydroxide, and sodium hypochlorite, the use of sodium chlorite is of particular interest. Mention should be made of the Münich process of Kesting. The soda semichemical process is also of value in pulping mixtures of very heterogeneous woods, which can be bleached by sodium chlorite or chlorine dioxide. The process yields pulp with very high strength properties, provided a high degree of bleaching is attained.

SUMMARY

In order to obtain high strength properties in papers it is necessary to retain the hemicelluloses which act as a cementing agent and to provide a cementing surface which results from the thick cell wall and the fibrillation in beating. A mild softening agent, such as a dilute sodium hydroxide solution at 100°, preserves the necessary amount of hemicelluloses for the cementing effect. A semichemical process is the best means to achieve this result. The problem of the utilization of hardwoods as a raw material for pulp and paper, and especially tropical woods of mixed composition, seems to be solved through the use of the semichemical process.

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Chemical Pulps from Australian Eucalyptus

ALEXANDER MELLER

In the utilization of woods for papermaking purposes, the purity of the pulps, as assessed by their cellulose content, is not of primary importance. In the production of dissolving grade or chemical wood cellulose, the purity plays a very important role. Although fiber length is a very important factor in utilizing fibers for papermaking, its role in chemical conversions of cellulose for the production of cellulose derivatives is probably of less significance. The recognition of the latter factor and the fact that eucalyptus woods are the main source of cellulosic raw material for making chemical cellulose in Australia induced an investigation on the production of such pulps from short-fibered Australian eucalyptus woods.

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Because of the availability of eucalyptus sulphate pulps in Australia, the first attempts for producing dissolving grade eucalyptus wood cellulose were concerned with purification processes applied to such pulps.

ALKALINE PURIFICATION OF EUCALYPTUS SULPHATE PULPS

The hot alkaline purification process, constituting essentially an integral part of many modern multistage bleaching processes and successfully applied to soft and hardwood sulphite pulps, has not been found promising when applied to hardwood sulphate pulps (*1*, *2*). Therefore, the cold alkaline purification process was applied to fully bleached eucalyptus sulphate pulps. This process uses strong alkaline solutions at relatively low temperatures. Some of the characteristic results of the relevant investigation are shown in Tables I, II, and III.

Table I. Processing Conditions and Yield of Unbleached and Bleached Eucalyptus Sulphate Pulps

Pulping conditions
20% NaOH on oven-dry weight of wood (22% sulphidity); wood–liquor ratio 1:4; pressure, 80 p.s.i.; time schedule, $^3/_4 + {}^3/_4 + 2^1/_2$ hr.
Bleaching conditions
First stage: 4.8% chlorine; 3.5% pulp concentration; 15 min.; lime neutralization and additional bleaching for 45 min.; 20°C.
Second stage: 2% NaOH on pulp; 2.5% pulp concentration; 1 hr.; 55°C.
Third stage: 1.7% chlorine (calcium hypochlorite); 10% pulp concentration; $1^1/_2$ hr.; 32–35°C.; pH 8.5–9.5
Pulp yield
Unbleached, 50–52%
Bleached, 46–48%

Table II. Chemical Characteristics of Unbleached and Bleached Eucalyptus Sulphate Pulps

	Characteristics				
Pulp	*Lignin, %*	*Xylan, %*	*Resistant xylan, %*	*Alpha-cellulose, %*	*Viscosity in cupram-monium hydroxide, poises*
Unbleached	0.9	17.2	...	...	34.4
Bleached	...	16.0	5.9	87.4	1.4

The cold alkaline purified pulps show a comparatively high alpha-cellulose content (95 to 96%) and a moderately low xylan content (6 to 8%), when compared with the bleached sulphate pulp from which they were prepared. They contain, however, a rather high "resistant xylan" fraction—i.e., a fraction of the pentosans which resists the dissolving action of 7% aqueous sodium hydroxide solution. This high "resistant xylan" fraction may be responsible for processing difficulties encountered in converting wood celluloses into cellulose derivatives or regenerated cellulose (*3*). It was found in a subsequent investigation (*2*, *4*) that the "resistant xylan" fraction of sulphate pulps can be reduced by acid treatment or more efficiently by alkaline hypochlorite bleaching prior to the cold alkaline purification. However, the pulps produced were somewhat drastically degraded and their "resistant xylan" content was still comparatively too high.

WATER PRECOOKING AND SULPHATE PULPING OF EUCALYPTUS WOODS

In the next phase of the investigation on the production of chemical or dissolving pulps from eucalyptus woods, certain principles of developments described in United States patents (*5*) and by German workers (*6–13*) were applied. It was observed that, on heating eucalyptus wood chips with water under pressure, organic acids were set free and that the water-cooked woods delignified readily by alkali solutions. Based on these observations, a process has been developed which consists of heating eucalyptus wood chips with water at pressures of 90 to 100 p.s.i., to such extent that the woods in their precooked (modified) form can be delignified by sulphate pulping under mild conditions—

Table III. Conditions of Cold Alkaline Purification Applied to Bleached Eucalyptus Sulphate Pulp, and Chemical Characteristics of Purified Pulps

Purifying conditions: (A) 10% NaOH; 10% pulp concentration; 2 hr.; 15°C. (B) 7.5% NaOH; 10% pulp concentration; 2 hr.; 20°C.

	Yield and chemical characteristics				
Pulps	*Yield on wood, %*	*Alpha-cellulose, %*	*Xylan, %*	*Resistant xylan, %*	*Viscosity in cupram-monium hydroxide, poises*
Cold alkaline purified (A)	36–38	96.1	7.7	5.5	1.0
Cold alkaline purified (B)	36–38	94.8	5.9	3.5	0.8
Bleached eucalyptus sulphate (unpurified)	46–48	87.4	16.0	5.9	1.4

Table IV. Properties of Eucalyptus Wood Samples and Water-Cooked (Hydrolyzed) Woods

	Wood samples		*Water-cooked woods*[a]	
Characteristics	*46S113*	*48S163*	*47C138*	*48C163 & 164*
Xylan, %	17.4	18.1	5.1	5.2
Lignin, %	17.2	18.7	28.1	31.9
Solubility in alcohol-benzene, %	2.5	3.2	12.3	16.3
Xylan removed by alcohol-benzene, %	...	...	1.3	1.7
Lignin content of alcohol-benzene extracted residue, %	21.0	21.6	23.9	25.0
Solubility in cold 5% NaOH solution, %	11.4	12.8	20.1	24.7
"Difficultly soluble xylan," %	14.3	14.7	1.5	1.3
Xylan removed by cold 5% NaOH solution, %	3.1	3.4	3.6	3.9
Hot water solubility, %	3.9	3.9	...	...
Total removed by hot 2% NaOH solution (2 hr.), %	13.5	15.1	36.2	42.8
Xylan removed by hot NaOH solution (2 hr), %	3.5	3.2	3.7	3.8
Lignin removed by hot 2% NaOH solution (2 hr), %	...	...	19.7	24.3

[a] Conditions applied in water cooking (hydrolysis): wood–water ratio: 1:4; time schedule: $^1/_2$ + 3 hr. Cook 47C138 at 95 p.s.i. pressure. Cook 48C163 and 164 at 97 p.s.i. pressure.

Table V. Conditions Applied in Water Cooking (Hydrolysis) and Pulping Stages, Pulp Yield, and Characteristics of Unbleached Pulps

Wood sample	Water cook	Water cooking conditions[a] (pressure, p.s.i.)	Yield of water-cooked wood, %
46S113	47C119 & 47C138	95	78
48S163	48C163 & 48C164	97	82

			Sulphate pulping conditions[b]			
Wood sample	Water cook	Sulphate cook	NaOH on water-cooked wood, %	Pressure, p.s.i.	Time schedule, hr.	Yield of sulphate pulp, %
46S113	47C119	47K134 & 137	20	60	$3/4 + 3/4 + 2\,1/2$	32
46S113	47C138	47K143	18	45, then 60	$1/2 + 1\,1/2 + 1$ then $1/2 + 1$	...
48S163	48C163 } 48C164 }	48K167	20	45, then 60	$1/2 + 1\,1/2 + 1$ then $1/2 + 1$	32.5

	Characteristics			
Sulphate pulp	Lignin, %	Permanganate no. (TAPPI)	Xylan, %	Viscosity in cuprammonium hydroxide, cp.
47K134 & 137	1.9	8.0	1.9	1512
47K143	1.8	7.0	1.5	3402
48K167	1.7	7.8	1.4	7224

[a] Wood-water ratio: 1:4; time schedule: 1/2 + 3 hr.
[b] Water-cooked wood–liquor ratio: 1:4; sulphidity of cooking liquor: 22%; time schedules: 3/4 hr. relief, 3/4 hr. to pressure, 2 1/2 hr. at pressure; 1/2 hr. relief, 1 1/2 hr. to pressure, 1 hr. at pressure (45 p.s.i.); 1/2 hr. to pressure and 1 hr. at pressure (60 p.s.i.)

i.e., applying only 60 p.s.i. pressure (*14*). The conditions applied in the water-precooking sulphate pulping and bleaching stages are listed in Table V, and the chemical characteristics of the wood celluloses in Table VI.

The eucalyptus celluloses produced by the process described above were of high purity. Besides the high alpha-cellulose (93 to 95%) and low xylan (1.5%) content, they contained a very low "resistant xylan" fraction (1%). The purity of these celluloses approximates that of softwood dissolving celluloses produced by sulphite pulping and alkaline refining.

Table VI. Conditions Applied in Bleaching and Characteristics of Bleached Eucalyptus Celluloses

		Bleaching conditions[a]		
Sulphate pulps	Bleach no.	Stage I[b] Cl, %	Stage II[c] NaOH, %	Stage III[d] Cl, %
47K134 & 137	47B18	2.75	2	0.4
47K143	47B20	4.0	2	0.8
48K167	48B132	3.0	2	0.5

	Characteristics of bleached pulps			
Bleach no.	Xylan, %	Resistant xylan, %	Alpha-cellulose, %	Viscosity in cuprammonium hydroxide, cp.
47B18	1.6	1.3	90.6	67.2
47B20	1.5	0.9	93.4	79.8
48B132	1.8	1.0	95.5	92.4

[a] After alkaline extraction and water washing, 0.2% chlorine was applied in the form of chlorine water, followed by washing.
[b] Pulp stock concentration in bleaches 47B18 and 47B20 was 4.25%, and in 48B132 it was 2.8%.
[c] Pulp stock concentration was 8 to 10%, temperature 50 to 60°C., the period of extraction 2 hr.
[d] Pulp stock concentration was 8 to 10% and the temperature 32 to 35°C.; pH was kept between 9 to 10.

It may be of interest to discuss briefly the values listed in Table IV. They show some chemical characteristics of eucalyptus wood samples before and after water cooking. There is an apparent increase in lignin content as determined by the method of analysis resulting from water cooking. This may be related to the formation of acid-insoluble condensation and polymerization products. The real change of the lignin fraction of the woods, however, is not in quantity but in its response to hot alkaline solutions. Water precooking of eucalyptus woods rendered the lignin and xylan fractions readily removable by alkali solutions, indicating that some extensive chemical or physical structural changes with the woods may have taken place in the water precooking step (*14*). That the wood has been extensively modified in chemical or physical constitution is borne out by the values for the alcohol-benzene solubility.

The methods of tests and interpretations summarized in Table IV may serve to evaluate the quality and suitability of woods for pulping (*14*). The differences between the characteristics of the two wood samples prevail not only after water precooking but also after pulping and bleaching, as shown by the relevant values in this table. Further developments of the methods of testing and interpretation of the results along the lines presented in this table may contribute to a better understanding of the chemistry of woods and may be useful in controlling the process for the production of dissolving-grade wood celluloses.

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Chemical Utilization of Tropical Hardwoods

Notes on Current Work at The Forest Products Research Laboratory, Princes Risborough, England

R. H. FARMER and W. G. CAMPBELL

THE work to be described here in general outline is sponsored by the Colonial Products Research Council, a body specially set up by the British Colonial Office after the second World War to foster research and development work in research institutions, universities, and elsewhere on all kinds of economic or potentially economic products of the British colonies. Of these products, timber is one of the most important. In the first instance, our attention has been directed by the Research Council to the forests of British Guiana where the full utilization of the forest crop presents very considerable difficulty.

The salient features of the forests of British Guiana are the absence of softwoods (gymnosperms) and a marked lack of medium-weight hardwoods. Over 80% of the enumerated hardwood species weigh over 50 pounds (bulk density, 0.80) and some 66% weigh 60 pounds (bulk density, 0.96) or more per cubic foot at a moisture content of 15%. The woods of some genera such as *Eschweilera* (manbarklak) and *Licania*, besides being very heavy [over 70 pounds per cubic foot (bulk density, 1.12)], are highly siliceous which renders them extremely difficult to work with tools. The best-known heavy timber of British Guiana is, of course, greenheart (*Ocotea sp.*) which is well known because of its great durability toward fungal decay and its resistance to marine borers. In the so-called Bartica Triangle, one of the more accessible forest areas in British Guiana, which is about to be developed by the Colonial Development Corporation (another independent body set up by the Colonial Office), greenheart only represents 16% of the crop. Of the remainder, some 22% of the crop is represented by wallaba (*Eperua sp.*) and morabukea (*Mora gonggrijpii*) and mora (*Mora excelsa*), two closely related species, together make up a further 20%. Wallaba is a very durable timber and is used in the untreated state as transmission poles, railroad ties, roofing and siding shingles, etc., but mora and morabukea at 56 to 66 pounds per cubic foot (bulk density, 0.90–1.05) in each case are only moderately durable and they present difficulties in sawing and seasoning. There is at present a measure of uncertainty in official quarters concerning possible economic outlets through the more usual channels of physical utilization for all the wallaba, mora, and morabukea likely to become available when large-scale extraction commences and it is felt that a measure of chemical or semichemical utilization, if applicable, might help to ease the situation.

So far as wallaba is concerned, a considerable amount of chemical exploration has already been carried out. The wood, especially the heartwood, is very resinous and of relatively high calorific value [9260 B.t.u. per pound for heartwood and 8980 B.t.u. per pound for sapwood (oven-dry)]; the normal value for hardwoods is about 8500 B.t.u. per pound. The bulk density of the wood is 0.75 to 1.04. Although it is much more dense than the average hardwood used in the pulping industry, laboratory-scale trials sponsored by the Colonial Office and others have indicated that wallaba can be pulped by the sulphate and soda processes, the resin being readily soluble in the cooking liquor. The average fiber length of wallaba wood is 1.4 mm. and the average fiber diameter is 0.015 mm. There appears to be some doubt, however, whether pulp or paper of the qualities obtainable from wallaba could be exported at a profit under current economic conditions.

The chemical research project on tropical woods at the British Forest Products Research Laboratory is divided into two parts. First, the woods are analyzed and, if they are rich in extractives, these latter form the subject of a separate evaluation. Second, the potentialities of the woods as a raw material for manufacture of fiberboard are examined from a technical standpoint in a laboratory-scale plant specially designed for the purpose after receiving much helpful advice from the U. S. Forest Products Laboratory. Up to the present time, the woods under investigation have been wallaba, mora, and morabukea. As a first step a considerable amount of work was carried out on wallaba resin.

The percentage of resin in wallaba wood varies considerably from sample to sample. Sapwood may contain less than 10% by weight (oven-dry) but heartwood may contain up to 30% or more. The constitution of this resin is unknown. It is not of the abietic acid type but is rather of a phenolic nature. Catechol is readily obtained from it on destructive distillation. The resin is soluble in alcohol and acetone but only slightly soluble in water and most organic solvents. Its elementary composition is C, 63.69%; H, 5.67%; N, 1.11%; S, 0.10%; O, 29.43%. The destructive distillation of this resin has been studied by us in some detail and a procedure evolved for the production from it of a high grade of metallurgical coke as a major end product. The yields of coke and volatile products from wood of 25% resin content are shown in Fig. 1.

The nonaqueous part of the liquid distillate of wallaba resin has been found, in mycological tests, to be highly toxic to wood-destroying fungi and to be approximately equivalent to pure phenol in this respect. It would, therefore, be useful as a wood preservative. The greater part of the gas evolved during the distillation of the resin is combustible and, in a large-scale operation,

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could probably be recycled and burned to provide part of the heat required for the distillation itself. From a technical point of view, therefore, a scheme for the complete conversion of wallaba resin into usable products has been made available. Present information indicates, however, that although the coke referred to would command a high price, the exploitation of wallaba wood for the resin alone would not be commercially feasible. Some use for the chipped wood after extraction of the resin is required and a natural suggestion to this end is fiberboard.

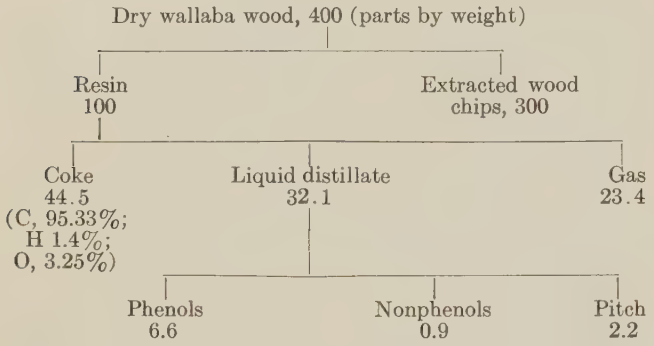

Fig. 1. Products of destructive distillation of wallaba resin

Because of its hardness and high density, the chipping of wallaba wood presents some difficulty. A small heavy-duty chipper has therefore been designed and recently installed at the Princes Risborough Laboratory. This chipper has a heavy 2-foot diameter mild steel disk upon which are mounted two knives of 0.8 to 0.9 carbon steel. The machine is powered by a 15-hp. motor and has been found to convert 4 by 3-inch pieces of wallaba into $^1/_2$-inch chips of good quality with very little production of dust. Softening of the chips for defibration requires chemical treatment and the best results achieved so far involve production of semichemical pulp by means of sodium sulphite, together with a proportion of sodium carbonate or bicarbonate. The resin is readily sulphonated in the course of a 2-hour cook at 100 p.s.i. pressure, and remains in solution in the spent liquor. Present indications are that when the resin is left in the wood, the sulphite consumption is about 10% of the dry weight of the wood, and may be somewhat less if the chips are previously extracted to remove the resin. The cooked chips are readily defibered in a beater with wide spacing between roll and bedplate, this being the only means of defibration available to us at present. Samples of hardboard of good quality, measuring 10 by 10 inches, have been made from these semichemical pulps.

The greater part of the resin can be extracted from the $^1/_2$-inch chips with alcohol, and experiments are in progress to determine the suitability of the extracted chips for fiberboard production. In this way it is hoped to establish the technical requirements for a dual process of utilization involving (1) extraction of resin (with solvent recovery) followed by coke and wood preservative production, and (2) production of hardboard from extracted chips.

At this stage, attention is drawn to the results of an independent investigation on wallaba wood and resin

Table I. Distribution of Saponin in Mora Heartwood

Tree	Height from ground, ft.	Alcohol-soluble material, % — Center	Alcohol-soluble material, % — Intermediate	Alcohol-soluble material, % — Outer	Saponin, % — Center	Saponin, % — Intermediate	Saponin, % — Outer
2	48	9.2	12.7	16.0	6.5	6.3	5.9
3	18	....	10.6	....	...	2.8–3.5	...
6	17	13.9	16.5	17.6	7.2	7.6	8.4
	36	14.1	15.9	19.1	6.4	8.1	7.9
	47	19.4	17.5	16.8	8.1	9.5	9.6

carried out in England by Fleck and Schueler (*1*). These authors have patented a process whereby isolated wallaba resin, or a considerable part of it, can be reacted with aldehydes to form thermoplastic or thermosetting resins. They also claim that the entire wood can be ground and the resinous component reacted with aldehydes *in situ* so as to give a satisfactory and cheap molding powder. Therefore, there is a technical possibility that fiberboard could be made from wallaba wood by either a wet-forming or dry-forming process.

Work on mora and morabukea is not yet very far advanced. Mora heartwood has been found to have a very high content of extractives. Solubility in hot water or alcohol can be as high as 20% (oven-dry wood basis). The principal extractive is a saponin of the triterpenoid type which is readily extracted with hot alcohol and purified by precipitation with acetone. A limited survey (Table I) shows that the saponin content of mora heartwood is variable between approximately 3 and 10%. The variation in saponin content between one tree and another appears to be greater than that between different parts of the same tree and it would appear that the upper part of the stem of any given tree is richer in saponin than the lower part.

Hydrolysis of mora saponin gives rise to a mixture of sugars (chiefly glucose and xylose) and a complex mixture of crystalline sapogenins. These latter have been separated with some difficulty by fractional crystallization and one of them has been shown in a detailed constitutional study by D. H. R. Barton and collaborators (*2*) at the Universities of London and Harvard to be a hitherto unknown triterpenoid carboxylic acid. It has been named "morolic" acid. The sapogenins of mora also include oleanolic acid, which is well known as a hydrolysis product of other saponins.

Morabukea heartwood also contains a saponin which has been obtained on a laboratory scale in 4% yield by the same technique already described for the isolation of mora saponin. The principal sapogenin obtained on hydrolysis of morabukea saponin is oleanolic acid. No morolic acid is obtained in this case.

There would appear to be no immediate prospect of finding a profitable outlet for the saponins of mora and morabukea. Information obtained from a trade source in England indicates that yields are low compared with those obtained from current commercial sources of saponin powder. The indications are, therefore, that the production of saponin from these woods is unlikely to be feasible commercially unless a profitable outlet can be found for the fibrous residue remaining after extraction of the saponin. The possibility of converting this material into fiberboard is therefore envisaged and experimental work to this end will soon be in progress.

Owing to very considerable delays in obtaining small-scale plant suitable for fiberboard studies, this part of the work is much less advanced than the laboratory investigation of the wood extractives. Full details of the results obtained so far have already been published (*3, 4*) and other wood species will be investigated along the same lines. Where new substances are brought to light, it is proposed to determine the best method of isolating them in a pure condition and to characterize them chemically as far as possible with the resources available at Princes Risborough. Samples are then prepared for fuller examination by specialists in university or industrial laboratories, with which the Forest Products Research Laboratory is in touch.

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Pulping of Tropical Woods and Other Indigenous Cellulosic Raw Materials

R. V. BHAT

The present production of writing and printing papers in India is about 75,000 tons per year and the present consumption of these papers is about 130,000 tons per year. With the literacy drive and the various development programs which State Governments in India have launched, the consumption of paper in this country is bound to go up in the next few years. To meet, at least partially, the current requirements of paper, some paper mills in this country have undertaken expansion programs and some new units are being installed. The chief fibrous raw materials used for the manufacture of paper in this country are bamboo and sabai grass (*Eulaliopsis binata*, Retz., C. E. Hubbard). Bamboo is used to the extent of about 63% of the total fibrous raw materials and sabai grass 22%. The paper mills are finding it difficult to get enough of these raw materials to work to their present full capacity. They are using waste paper, old rags, and imported wood pulp to make up the deficiency. The current price of imported wood pulp is more than the price of paper manufactured in this country.

In order, therefore, to meet the present requirements of fibrous raw materials, as well as to produce more and more paper to satisfy the growing domestic demand for this commodity, the paper mills in India will have to use new cellulosic raw materials. Because of the large number of uses to which bamboo is put and the limited availability of sabai grass, the use of new cellulosic raw materials becomes imperative, especially when it is remembered that the Indian paper industry will have to nearly double its production to meet at least the current domestic requirements of writing and printing papers. To help the paper industry in this direction, intensive research work is being carried out at this Institute on the utilization of forest products and agricultural wastes for the production of paper and board of all kinds. Investigations carried out during the last year on the pulping of some tropical woods and other indigenous cellulosic raw materials are briefly described. The results of these investigations are being published in detail elsewhere.

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The supply of the more generally used fibrous raw material (viz., coniferous woods) for the paper industry in foreign countries is steadily decreasing. Hence, attempts are being made to use more and more of woods of broad-leaved species for the production of paper. In India conifers such as spruce (*Picea morinda*, Link) and silver fir (*Abies pindrow*, Spach) are found in the Himalayan region which is not easily accessible. These conifers, when exploited, will be required for special kinds of paper, such as newsprint. Indian forests are full of broad-leaved species. To meet the growing need for fibrous raw materials in the Indian paper industry, the utilization of broad-leaved woods provides one possible solution. Hence investigations were undertaken on the chemical, semichemical, and mechanical pulping of some tropical woods. In the selection of the species for these investigations, special attention was paid to the availability of the species on a large scale and the possibility of raising plantations in quick rotation.

CHEMICAL PULPS

Boswellia serrata Roxb. (salai). This broad-leaved species is found in dry forests throughout India except in Bengal and Assam. It is common in Madhya Pradesh, Bombay, Bihar, Deccan, Orissa, Central India, the Circars, and the Carnatic. It grows where other forest trees of greater commercial value refuse to thrive. It is found in the vicinity of some of the existing paper mills.

The wood without the bark was chemically analyzed by the Forest Products Laboratory methods (*1*), except in the case of pentosans where TAPPI Standard T 223 m-48 was employed. The results of the chemical analysis are given in Table I.

The fiber length of the pulps from this wood was determined by the procedure followed in this laboratory (*2*). The average fiber length of the pulp was 0.88 mm.;

Table I. Chemical Analysis of Tropical Woods[a]

	Boswellia serrata, %	Lannea grandis, %	Sterculia campanulata, %	Broussonetia papyrifera, %	Helicteres isora, %
Moisture	10.20	8.05	6.62	5.48	4.08
Ash	1.80	1.60	1.01	1.08	1.68
Cold water solubility	6.30	3.31	1.47	4.20	6.19
Hot water solubility	8.90	8.53	2.59	7.93	6.47
1% NaOH solubility	15.50	18.94	17.94	17.96	19.15
10% KOH solubility	32.80	31.09	25.87	30.59	29.10
Ether solubility	0.70	1.16	1.5	0.99	0.43
Alcohol-benzene solubility	4.30	1.59	1.48	1.92	5.63
Pentosans	13.0	15.40	15.51	16.43	16.00
Lignin	27.30	24.11	23.83	23.26	13.60
Cellulose (Cross and Bevan)	50.70	53.37	59.50	59.13	51.40

[a] All these are expressed on oven-dry basis except moisture.

the minimum and maximum values were 0.60 and 1.20 mm., respectively. The fiber diameter (*3*) of the pulp varied from 0.0135 to 0.0385 mm. with an average of 0.024 mm. The ratio of the average fiber length to diameter is 37:1.

In order to test the suitability of this wood for the production of writing and printing papers, a number of digestions were carried out under various conditions by the sulphate process, using caustic soda and sodium sulphide in the ratio 2:1. The quantity of chemicals was varied from 18 to 22% on the basis of the air-dry raw material, the temperature of digestion from 153 to 170°C., and the period of cooking from 4 to 8 hours. The optimum digestion conditions under the conditions studied are given in Table II, together with the yields of the unbleached and bleached pulps and the strength properties of the bleached pulp in Table III. It will be seen from these results that bleached pulps in satisfactory yields and with strength properties suitable for writing and printing papers can be prepared from *Boswellia serrata*. Because of the shortness of the fiber, pulps from this species must be mixed with pulps with longer fiber lengths (such as those from bamboo) for the production of writing and printing papers. Printing paper with satisfactory strength properties was prepared from a mixture of 75% *Boswellia serrata* pulp and 25% bamboo pulp. The July, 1951, issue of the *Indian Forester* was printed on this paper. For the pilot plant experiment, about 900 pounds (air dry) of chips of *Boswellia serrata* were taken for the digestion.

Lannea grandis Engler (syn. *Odina wodier*, Roxb.) (jhingan). This species is distributed throughout the hotter parts of India, the Andamans, Burma, and Ceylon. From the Beas in the northwest of India it extends along the lower Himalayas, ascending the valleys up to about 4000 feet. In the sub-Himalayan zone it is found in sal (*Shorea robusta*, Gaertn.) forests as far as Assam and in the mixed deciduous forests of the plains and outer hills. From the Tarai and Bhabar tracts it extends down through Bihar, Orissa, Madhya Pradesh to the Deccan Peninsula. It is found in large quantities in the vicinity of a paper mill in South India.

The wood of this species without the bark was chemically analyzed. The results of the analysis are given in Table I. The fiber length of the chemical pulp from the wood of this species was found to vary from 0.55 to 1.33 mm. with an average of 1.01 mm. The average fiber diameter of the pulp was 0.0244 mm. (minimum and maximum values were 0.0204 and 0.0324 mm., respectively). The ratio of the average fiber length to diameter is 41:1.

A number of digestions were carried out by the sulphate process, using caustic soda and sodium sulphide in the ratio 2:1. The quantity of total chemicals was varied from 20 to 24% on the weight of the raw material, the concentration of the cooking liquor from

Table II. Digestion Conditions for Tropical Woods and Pulp Yields

Serial No.	*Species used*	*Total chemicals*[a] *(NaOH:-Na_2S = 2:1), %*	*Concentration of chemicals, g./l.*	*Digestion temperature, °C.*	*Digestion period, hr.*	*Consumption of chemicals,*[a] *%*	*Unbleached pulp yield,*[a] *%*	*Bleach consumption,*[c] *%*	*Bleached pulp yield,*[a] *%*	*Remarks*
1	*B. serrata*	20	50	[b]	6	18.5	44.7	7.2	41.9	Well-cooked pulp was obtained
2	*L. grandis*	22	50	153	6	20.7	49.1	8.0	46.2	Well-cooked pulp was obtained
3	*S. campanulata*	22	55	142	5	20.6	53.3	5.0	51.2	Well-cooked pulp was obtained
4	*B. papyrifera*	24	45	153	6	22.0	52.0	8.7	48.1	Well-cooked pulp was obtained
5a	*H. isora*	22	55	153	6	19.1	42.7	7.3	34.2	The sulphate process was used. Well-cooked pulp was obtained
5b	*H. isora*	22	55	153	6	16.8	43.5	8.7	38.6	The soda process was used. The wood was used with the bark. Well-cooked pulp was obtained

[a] The percentage, as standard bleaching powder containing 35% available chlorine, is expressed on the basis of the air-dry raw material, except in the case of *Brossounetia papyrifera* where the oven-dry weight of the raw material is considered for the calculation.
[b] 162°C. for the first hour and 153°C. for 5 hr.
[c] The percentage is expressed as standard bleaching powder containing 35% available chlorine.

Table III. Strength Properties of Standard Sheets from Bleached Pulps from Tropical Woods

Serial No.[a]	Species used	Freeness of pulp, ml. (C.S.F.)	Basis weight, g./sq. m.	Breaking length (Schopper), m.	Stretch, %	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper), double folds
1	*B. serrata*	236	59.4	5693	3.8	74.1	33.0	220
2	*L. grandis*	318	62.1	6667	4.2	72.6	47.4	272
3	*S. campanulata*	295	57.7	9860	4.0	100.0	52.0	2360
4	*B. papyrifera*	321	63.0	9010	5.0	81.8	48.2	1200
5a	*H. isora*	307	62.2	7405	3.8	85.2	41.3	180
5b	*H. isora*	238	63.7	6383	4.1	79.2	43.6	160

[a] Serial numbers in this table correspond to the serial numbers in Table II. The pulp sheets were conditioned at 65% R. H. and 70°F. before testing.

40 to 50 grams per liter, the temperature from 153 to 170°C., and the period of cooking from 4 to 6 hours. The optimum conditions of digestion under the conditions studied in the laboratory are given in Table II and the strength properties of the bleached pulp prepared under the optimum conditions in Table III. It will be seen from these results that chemical pulps in satisfactory yields can be prepared from *Lannea grandis*. The strength properties of these pulps are satisfactory. As these pulps are short fibered, they require to be mixed with long-fibered pulps (such as bamboo pulps) in order to run them on paper machines without breakage. Writing and printing papers with satisfactory strength properties were prepared from a mixture of 75% *Lannea grandis* pulp and 25% bamboo pulp.

Sterculia campanulata Wall. (papita) is found in the Andamans and Burma. Its wood is light cream in color. As described later, the wood of this species has been found to be a promising raw material for newsprint-grade mechanical pulp. It was thought desirable to test this species for the production of chemical pulp also.

The results of the chemical analysis of this wood without bark are given in Table I. The average fiber length of the pulp from this wood was found to be 1.49 mm.; the minimum and maximum values were 0.91 and 1.96 mm., respectively. The fiber diameter of the pulp varied from 0.0260 to 0.0450 mm. with an average of 0.0390 mm. The ratio of average fiber length to diameter is 38:1.

As a result of a number of digestions carried out by the sulphate process on a laboratory scale it was found that bleached chemical pulp in high yields and with high strength properties could be prepared from this wood. The quantity of chemicals was varied from 20 to 24% on the weight of the raw material, the temperature from 142 to 162°C., and the period of cooking from 3 to 6 hours. The optimum digestion conditions found as a result of these experiments are given in Table II and the strength properties of bleached pulps prepared under these conditions in Table III. It will be seen from these results that this wood is the best of all the tropical woods described here for the production of chemical pulps for writing and printing papers.

Broussonetia papyrifera Vent. (paper mulberry) is a fast growing deciduous tree. It is an exotic which is expected to thrive in moist localities. Recent plantation experiments carried out at Travancore (India) have indicated that this species can be grown there to pulpwood size in a few years. The inner fiber of the bark of this tree is used in Japan for making paper. The work carried out at this Institute has shown that this wood is suitable for the production of mechanical pulp for newsprint (*4*).

The results of the chemical analysis of this wood are recorded in Table I. The fiber length of the chemical pulp from this wood without bark varied from 0.54 to 1.2 mm. with an average of 0.82 mm. The fiber diameter of the pulp varied from 0.0174 to 0.0465 mm. with an average of 0.0302 mm. The ratio of the average fiber length to diameter is 27:1.

A number of digestions were carried out by the sulphate process, varying the quantity of chemicals from 20 to 26% on the weight of the oven-dry material, the temperature of digestion from 153 to 162°C., and the period of cooking from 5 to 6 hours. The optimum digestion conditions found as a result of these experiments are given in Table II and the strength properties of the pulp produced under these conditions in Table III. This wood is suitable for the production of bleached chemical pulp for writing and printing papers. Since the pulps are short fibered, it is necessary to mix them with pulps with longer fiber length (such as bamboo pulps) in order to run the stock without breakage on paper machines. Writing and printing papers with satisfactory strength properties were prepared in the pilot plant of this laboratory using a furnish consisting of 75% paper mulberry pulp and 25% bamboo pulp.

Helicteres isora, Linn. (Maror phal). This is a large shrub attaining the size of a tree, with thin spreading branches and gray bark. This species is distributed

Table IV. Digestion Conditions of Tropical Woods and Semichemical Pulp Yields

Serial No.	Species used	Chemicals for digestion[a] Sodium sulphite, %	Sodium carbonate, %	Material:-liquor ratio	Digestion temperature, °C.	Digestion period, hr.	Semi-chemical pulp yield,[a] %	Remarks
1	*L. grandis*	15	3.75	1:4	170	3	67.1	In all these experiments the digested chips were defibrated for $7\frac{1}{2}$ min. in the Asplund Defibrator
2	*L. grandis*	18	4.5	1:3.5	170	3	65.4	
3	*B. serrata*	18	4.5	1:3.5	170	3	60.2	
4	*G. pinnata*	18	4.5	1:4	170	3	65.2	
5	Mixture of *L. grandis*, *B. serrata*, and *G. pinnata*	18	4.5	1:4	170	3	63.8	

[a] The percentage is expressed on the weight of the air-dry raw material.

Table V. Strength Properties of Standard Sheets from Semichemical Pulps from Tropical Woods

Serial No.[a]	Species used	Freeness of pulp, ml. (C.S.F.)	Drainage time, sec.	Basis weight, g./sq. m.	Breaking length (Schopper), m.	Stretch, %	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper), double folds	Remarks
1	*L. grandis*	200	12	60.8	6169	...	88.8	40.3	693	In all these experiments the pulp was beaten in the Lampén mill
2	*L. grandis*	138	9	60.9	6371	2.8	78.8	34.4	363	
3	*B. serrata*	142	8	60.4	5086	2.8	63.8	25.0	63	
4	*G. pinnata*	140	7	60.8	3756	3.6	79.6	21.9	84	
5	Mixture of *L. grandis*, *B. serrata*, and *G. pinnata*	173	7	60.8	5052	4.5	85.2	30.1	164	

[a] Serial numbers in this table correspond to the serial numbers in Table IV. The pulp sheets were conditioned at 70% R. H. and 82°F.

in a sub-Himalayan tract from Jhelum to Nepal, Bihar, Central and South India, Western Peninsula, Ceylon, and probably Burma. It is also found in Java and northern Australia.

The bark of this wood is used for cordage. It has recently been reported that the experiments carried out under the auspices of the Forest Department, Uttar Pradesh (India) have shown that the bark of *Helicteres isora* has been found suitable as a substitute for jute in the preparation of gunny bags. The wood has a light cream color. This shrub grows gregariously in some forests. For these reasons the wood of this species was tested for its suitability for chemical pulp. The results of the chemical analysis of the wood of this species without bark are given in Table I. The fiber length of the pulp from this wood varied from 0.40 to 1.34 mm., with an average of 0.92 mm. The fiber diameter of the pulp varied from 0.0100 to 0.0230 mm. with an average of 0.0164 mm. The ratio of the average fiber length to diameter is 56:1.

The wood was digested with and without the bark under various conditions by the sulphate and the soda processes. In the case of the sulphate process, the quantity of chemicals was varied from 20 to 23%, the temperature from 153 to 170°C., and the period of cooking from 4 to 6 hours. In the soda process the quantity of alkali was varied from 20 to 24% and the temperature from 153 to 162°C.; the period of digestion was 6 hours. The optimum conditions of digestion in the case of the sulphate process using wood without bark are given in Table II and those in the case of the soda process using wood with the bark are given in Table II. The strength properties of pulps prepared under these conditions by the two processes are given in Table III. In order to obtain well-cooked pulp free from knots, the twigs of *Helicteres isora* were crushed between the rollers of the factory crusher before cutting into chips.

Table VI. Grinding Conditions of Tropical Woods and Screen Analysis of the Mechanical Pulps

Serial No.	1	2
Species used	*S. campanulata*	*A. stipulata*
Moisture in wood, %	30.0	55.0
Stone surface condition	Dull	Dull
Pressure of wood on stone, p.s.i.	38	16
Pit temperature, °C.	32	28
Pit consistency, %	1.7	1.2
Wood ground per 24 hours (oven-dry basis), cwts.	12.0	5.2
Energy consumed per ton of oven-dry wood, hp.-days	77	93
Screen analysis:		
Retained on 40-mesh, %	67	..
Retained between:		
40- and 120-mesh, %	7	..
120- and 200-mesh, %	2	..
Passing 200-mesh, %	24	..

Medium grain stone (Hercules make) was used for these grinding experiments. A 10-cut, 1 1/8 inch lead spiral burr was used

These experiments indicated that the stems of *Helicteres isora* could be used with or without the bark for making chemical pulps suitable for writing and printing papers. Chemical pulps could be prepared from this species by the sulphate or the soda process. The soda pulps consumed more bleaching powder than the sulphate pulps to attain the same degree of whiteness. Printing paper from *Helicteres isora* was prepared in the pilot plant of this laboratory and the June, 1951, issue of the *Indian Forester* was printed on this paper. This pilot plant experiment indicated that it is essential to mix *Helicteres isora* pulp with pulps of longer fiber length in order to work the stock smoothly on paper machines. Later, writing paper with satisfactory strength properties was made in the pilot plant from a furnish consisting of 60% *Helicteres isora* pulp and 40% sabai grass pulp.

SEMICHEMICAL PULPS

The advantages of the semichemical pulping processes are too well known to be discussed here. The semichemical process has been found to be suitable for the production of wrapping papers from hardwoods. Hence, experiments were carried out in this laboratory on the semichemical pulping of *Lannea grandis*. Sodium sulphite and sodium carbonate in the ratio of 4:1 were used. The method followed for the digestion of the chips was slightly different from the conventional method. The chips (400 grams) were filled in the vertical stationary experimental digester and the cooking liquor was added. The digester was then closed and the liquor was heated by means of burners applied from the outside. The contents of the digester were quickly brought to the required temperature and maintained at that temperature for the required period. After this, the digester was opened, the liquor poured off, and the softened chips were washed. These chips were converted into pulp in an Asplund defibrator. The pulp obtained in this way was beaten in the Lampén mill to the required degree of freeness. The color of the pulp was brown and suitable for wrapping papers. The digestion conditions of two of these experiments are given in Table IV and the strength properties of semichemical pulps obtained under these conditions in Table V. From these results it will be seen that the yield of the semichemical pulp is 65 to 67% on the weight of the raw material. The strength properties of the pulps are satisfactory for medium-grade wrapping papers.

In tropical forests a large number of species of hardwoods occur in one and the same forest. The

Table VII. Strength Properties of Standard Sheets from Mechanical Pulps

Serial No.[a]	Species used	Freeness, ml., (C.S.F.)	Drainage time, sec.	Basis weight, g./sq. m.	Breaking length (Schopper), m.	Stretch, %	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Remarks
1a	*S. campanulata*	120	18	61.8	2752	1.5	28.0	6.4	Only mechanical pulp was used
1b	*S. campanulata*	250	12	59.6	2938	1.7	68.0	9.3	Bamboo chemical pulp (30%) was mixed with 70% of mechanical pulp described in Table VI
2a	*A. stipulata*	95	19	59.6	2695	1.8	21.0	7.2	Only mechanical pulp was used
2b	*A. stipulata*	120	16	58.0	3714	2.3	46.0	14.5	Beaten bamboo chemical pulp (30%) was mixed with 70% of mechanical pulp described in Table VI

[a] Serial numbers in this table correspond to the serial numbers in Table VI. The pulp sheets were conditioned at 65% R. H. and 62°F.

availability of any one species, even in a reasonably large area, is not sufficient to maintain an economic papermaking unit. The establishment of conditions for digesting a mixture of such species will be of great help in the economic utilization of such woods. Work on the cooking of mixtures of species of tropical woods carried out in France has been described in the previous Reports of the Meetings of FAO Committee on Wood Chemistry (*5*, *6*). Since in some forests, *Lannea grandis* occurs in mixed stands associated with species such as *Boswellia serrata*, it was thought desirable to carry out the digestions of a mixture of this wood with salai and *Garuga pinnata*, Roxb. (kharpat). The chips of these three species were mixed in equal quantities by weight and pulps were prepared by the semichemical process, using 15 and 18% sodium sulphite; in each case 25% of sodium carbonate (on the basis of the sulphite) was used. The pulp had a brown color and was suitable for wrapping papers. The digestion conditions where 18% sodium sulphite and 4.5% sodium carbonate were used are given in Table IV and the strength properties of standard sheets from the pulp made under these conditions in Table V. For comparison the digestion conditions of semichemical pulps prepared from pure *Boswellia serrata* and *Garuga pinnata* and strength properties of standard sheets prepared from these pulps are given in Tables IV and V.

The experiments showed that good homogeneous pulps could be prepared by cooking a mixture of these three species of hardwoods. The breaking length of the pulp from pure *Lannea grandis* was the highest and that of the pulp from pure *Garuga pinnata* was the lowest. On comparing the semichemical pulps at the same freeness from the pure woods and the mixture in equal quantities from these three species, it was found that the breaking length of the pulp from the mixture was the mean of the breaking lengths of pulps from the pure woods. The bursting strength and folding endurance of the pulp from pure *Lannea grandis* were superior to those from pure *Boswellia serrata* and pure *Garuga pinnata*. The values for these strength properties of the pulp from the mixture of these three species fell between those of the pulps from the individual pure species. These results are in conformity with those reported by Villiere (*7*). The stretch of the pulp from the mixture of these three species, however, was considerably higher than that of the pulps from the individual pure species. The tear was also similarly higher. The yield of the pulp from the mixed species was the mean of the yields from the individual species.

MECHANICAL PULPS

Sterculia campanulata (papita). As mentioned earlier, conifers are found in India in the Himalayan region which is not easily accessible. Attempts are being made to exploit these woods for the production of mechanical pulp for newsprint. The quantity of wood available in this region may not suffice to meet the entire domestic demand for newsprint. Hence, tropical woods are being tested for their suitability for newsprint-grade mechanical pulp.

A number of grinding experiments were carried out on *Sterculia campanulata* from the Andamans. The laboratory grinding equipment described in an earlier publication (*8*) was used for these experiments. The grinding of the wood was carried out under various conditions, varying the stone surface, the peripheral speed of the stone, the pressure of the wood against the stone, the temperature of the stock solution in the grinder pit, and the consistency of the pulp suspension, in order to study the optimum conditions for producing

Table VIII. Chemical Analysis of Reeds and Grasses and Agricultural Wastes[a]

	Arundo donax, %	Phragmites karka, %	Themeda arundinacea, %	Vetiveria zizanoides, %	Ricinus communis, %	Corchorus capsularis, %
Moisture	9.11	7.67	12.59	7.05	7.03	7.00
Ash	3.58	3.09	7.41	5.75	2.84	0.52
Cold water solubility	9.20	0.68	6.53	5.30	13.55	1.06
Hot water solubility	11.26	3.56	10.77	10.18	13.70	1.14
1% NaOH solubility	34.89	26.57	36.25	36.81	30.87	25.93
10% KOH solubility	44.39	43.90	48.02	58.78	40.85	37.60
Ether solubility	0.12	0.11	0.24	4.63	1.56	0.72
Alcohol-benzene solubility	6.79	2.91	3.57	7.86	5.34	1.23
Pentosans	18.36	22.49	22.03	25.45	16.19	18.76
Lignin	21.97	25.70	31.48	25.80	19.30	21.39
Cellulose (Cross and Bevan)	58.00	55.23	54.52	45.83	51.60	57.60

[a] All values are expressed on oven-dry basis except moisture.

Table IX. Digestion Conditions of Reeds and Grasses and Agricultural Wastes and Pulp Yields

Serial No.	Species used	Total chemicals,[a] %	Concentration of chemicals, g./l.	Digestion temperature, °C.	Digestion period, hr.	Consumption of chemicals,[a] %	Unbleached pulp yield,[a] %	Bleach consumption,[b] %	Bleached pulp yield,[a] %	Remarks
1	*A. donax*	17	40	162 for the first hour and 153 for the remaining period	6	15.8	42.6	5.39	36.3	Reeds without leaves were used by the sulphate process. In this as well as Serial Nos. 2–13 well-cooked pulps were obtained
2	*A. donax*	17	40	162 for the first hour and 153 for the remaining period	6	15.8	35.0	5.33	30.0	Reeds with leaves were used by the sulphate process
3	*A. donax*	18	40	162 for the first 3 hours and 153 for the remaining period	6	15.7	45.0	6.02	38.3	Reeds without leaves were used by the soda process
4	*A. donax*	18	40	162 for the first 3 hours and 153 for the remaining period	6	17.0	35.0	5.33	27.1	Reeds with leaves were used by the soda process
5	*P. karka*	22	40	153 for the first 2 hours and 162 for the remaining period	6	21.3	43.3	8.30	41.6	The sulphate process was used
6	*P. karka*	22	60	162	6	21.1	46.0	7.60	40.0	The soda process was used
7	*T. arundinacea*	18	36	162	4	15.7	41.2	5.30	30.9	The sulphate process was used
8	*T. arundinacea*	17	34	142	6	13.1	43.1	3.50	35.8	The soda process was used
9	*V. zizanoides*	16	32	153	5	11.3	43.6	7.76	31.0	The soda process was used
10	*R. communis*	22	55	162 for the first 3 hours and 153 for the remaining period	6	19.7	44.6	6.51	41.3	The sulphate process was used
11	*R. communis*	24	60	162	6	21.1	43.7	6.53	39.4	The soda process was used
12	*C. capsularis*	24	30	162	6	23.3	45.7	8.36	44.0	The sulphate process was used
13	*C. capsularis*	24	30	162	6	23.1	45.6	12.80	42.0	The soda process was used

[a] The percentage is expressed on the basis of the air-dry raw material.
[b] The percentage is expressed as standard bleaching powder containing 35% available chlorine.

mechanical pulp suitable for newsprint. The best conditions found for grinding are given in Table VI and the strength properties of standard sheets from the mechanical pulp made under these conditions in Table VII. Standard sheets were prepared using a mixture of 70% mechanical pulp from this wood and 30% unbeaten bamboo bleached chemical pulp. The strength properties of these sheets are given in Table VII. The color of the mechanical pulp was suitable for newsprint. *Sterculia campanulata* is thus a promising raw material for the production of mechanical pulp for newsprint.

Albizzia stipulata Boivin (siran). This is a fast-growing deciduous tree, which is found in the sub-Himalayan tract from the Indus eastward, Bihar, Bengal, South India and the Andamans. The grinding experiments carried out thus far have shown that this is a promising raw material for the production of mechanical pulp for newsprint, considering the color and strength properties of its mechanical pulp. The optimum grinding conditions found so far are given in Table VI and the strength properties of standard sheets made from this pulp in Table VII. Standard sheets were prepared by mixing 70% of this ground-wood pulp with 30% beaten bamboo bleached chemical pulp; the strength properties of these sheets are given in Table VII.

OTHER INDIGENOUS CELLULOSIC RAW MATERIALS

Arundo donax Linn. (narkul). This reed grows in certain parts of India, Burma, North Asia, North Africa, and Europe. In India it is generally found in the lower Himalayan region from Kashmir to Nepal at an altitude of about 3500 feet and from the Punjab to Assam, the Uttar Pradesh Tarai, the Naga Hills, the Circars, the Nilgiri Hills, and the Coorg Hills. It grows abundantly in moist places along the ditches and streams but it will also grow on dryish soil when established.

The chemical analysis of the reed without the leaves is given in Table VIII. The fiber length of the chemical pulp from this reed varied from 0.80 to 2.80 mm. with an average of 1.45 mm. The fiber diameter of the pulp varied from 0.0040 to 0.0360 mm. with an average of 0.0144 mm. The ratio of the average fiber length to diameter is 101:1.

A number of digestions were carried out by the soda

Table X. Strength Properties of Standard Sheets from Bleached Pulps from Reeds and Grasses and Agricultural Wastes

Serial No.[a]	Species used	Freeness of pulp, ml. (C.S.F.)	Basis weight, g./sq. m.	Breaking length (Schopper), m.	Stretch, %	Tear factor (Marx-Elmendorf)	Burst factor[b] (Ashcroft)	Folding endurance (Schopper), double folds
1	*A. donax*	175	63.1	9348	4.8	116.0	57.0	1168
2	*A. donax*	175	62.0	9650	4.5	113.0	58.0	1347
3	*A. donax*	180	62.3	9325	4.1	114.0	54.0	1407
4	*A. donax*	135	63.0	9017	4.0	90.0	54.0	1248
5	*P. karka*	200	62.2	7000	4.0	60.0	32.0	90
6	*P. karka*	320	60.8	6000	3.6	70.0	32.0	80
7	*T. arundinacea*	292	61.6	7089	3.6	81.6	34.8	480
8	*T. arundinacea*	227	62.4	8085	4.6	86.9	48.9	650
9	*V. zizanoides*	185	63.0	9466	4.0	68.3	50.6	370
10	*R. communis*	263	53.8	8400	3.5	68.3	52.6	2120
11	*R. communis*	307	63.0	7787	3.0	65.0	44.4	750
12	*C. capsularis*	330	60.6	8320	2.5	59.4	58.9	540
13	*C. capsularis*	160	59.6	7600	2.5	42.2	47.3	160

[a] Serial numbers in this table correspond to serial numbers in Table IX. The pulp sheets were conditioned at 65% R. H. and 70°F.
[b] In the case of serial numbers 1–4 and serial numbers 10 and 11, Mullen burst tester was used.

and sulphate processes in order to find out the optimum conditions of digestion. In the sulphate process a mixture of caustic soda and sodium sulphide in the ratio of 2:1 was used. The reeds with leaves, as well as without leaves, were used for digestion. The optimum digestion conditions found by the sulphate process are given in Table IX and the strength properties of standard sheets made from these pulps in Table X. The optimum digestion conditions by the soda process are given in Table IX and the strength properties of the pulps made under these conditions in Table X. The results of these experiments indicated that *Arundo donax* was a suitable raw material for the production of chemical pulp for writing and printing papers. Printing paper was made from this species in the pilot plant of this laboratory and the September, 1951, issue of the *Indian Forester* was printed on this paper.

Phragmites karka Trin. (nal). This species grows in habitats suitable for *Arundo donax*. It grows abundantly in Assam. It is also found in the Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay, and Madras. The results of the chemical analysis of this reed without the leaves are given in Table VIII. The fiber length of the chemical pulp from this reed shorn of leaves varied from 0.50 to 3.20 mm. with an average of 1.20 mm. The fiber diameter of the pulp varied from 0.0066 to 0.0198 mm. with an average of 0.0116 mm. The ratio of the average fiber length to diameter is 103:1.

A number of digestions were carried out by the sulphate and the soda processes. The reeds were pulped without the removal of the leaves. The optimum digestion conditions found by the sulphate and the soda processes are given in Table IX and the strength properties of the pulps made under these conditions in Table X. The results of these experiments indicated that *Phragmites karka* required more chemicals for pulping than does *Arundo donax*. Printing and writing papers were made from *Phragmites karka* in the pilot plant of this laboratory. These experiments indicated that admixture with pulps with longer fiber length (such as sabai grass pulps) was necessary for making writing and printing papers from pulps of *Phragmites karka*. Pilot plant experiments also showed that good pulp could be produced by cooking a mixture of *Arundo donax* and *Phragmites karka*.

Themeda arundinacea Ridley (syn. *Anthistiria gigantea* Cav.) (ulla grass). This grass is found in the lower Himalayan region from Kumaon eastward to Assam, Bihar, Orissa, Naga, and Kahasi Hills. The chemical analysis of this grass is given in Table VIII. The fiber length of the chemical pulp from this grass varied from 0.64 to 6.82 mm. with an average of 2.88 mm. The fiber diameter varied from 0.0096 to 0.0350 mm. with an average of 0.0160 mm. The ratio of average fiber length to diameter is 170:1. It is known that sheet formation is good if the ratio of average fiber length to diameter is high.

A number of digestions were carried out by the sulphate and the soda processes. The optimum digestion conditions found by the sulphate and the soda processes are given in Table IX and the strength properties of pulp prepared under these conditions in Table X. From these results it will be seen that this grass is a suitable raw material for the production of chemical pulp for writing and printing papers.

Vetiveria zizanoides Stapf. (panni grass). This grass is found in the Punjab, Uttar Pradesh, Bengal, Madhya Pradesh, Bombay, and Madras. The chemical analysis of this grass is given in Table VIII. The fiber length varied from 0.42 to 3.83 mm. with an average of 1.20 mm.

A number of digestions were carried out by the soda process. The optimum digestion conditions found are given in Table IX and the strength properties of the pulp made under these conditions in Table X. Pilot plant experiments were also carried out. From the results of these experiments it was concluded that writing and printing papers could be made by mixing about 30 to 40% of sabai grass pulp with panni grass pulp.

Ricinus communis Linn. (arand). The caster oil plant of the annual variety is cultivated in many parts of India for the seeds. After the harvesting season is over, the stems are allowed to dry in the field until they are cut by the cultivator for burning. There is no special use for these stems. Hence, they were tested for their suitability for papermaking.

The results of the chemical analysis of the stems of the castor oil plant with the bark are given in Table VIII. The fiber length of the chemical pulp from the stems without the bark varied from 0.50 to 0.94 mm. with an average of 0.81 mm. and that of the pulp with the bark from 3.47 to 9.29 mm. with an average of 5.48 mm.

A number of digestions were carried out by the sulphate and the soda processes. The stems were used with the bark. The optimum digestion conditions

found by these processes are given in Table IX and the strength properties of the pulps prepared under these conditions in Table X. The results of these experiments indicated that the stems of the castor oil plant were suitable for the production of chemical pulp for writing and printing papers.

Corchorus capsularis Linn. (pat). The results of chemical analysis of jute sticks are given in Table VIII. The fiber length of the chemical pulp from this material varied from 0.59 to 1.07 mm. with an average of 0.80 mm. The fiber diameter of the pulp varied from 0.0167 to 0.0375 mm. with an average of 0.0291 mm. The ratio of the average fiber length to diameter is 27:1.

The optimum digestion conditions found by the sulphate and the soda processes are given in Table IX and the strength properties of the pulps made under these conditions in Table X. The consumption of chemicals for pulping was high. Since the pulps are short fibered, it will be necessary to mix these pulps with long-fibered pulps (such as bamboo pulp).

PULPS FOR STRAWBOARD

Of a number of strawboard mills in India, only four are large units with an annual rated capacity of 6000 to 8000 tons of boards. Wheat straw is well suited for the production of strawboard but this is required for cattle fodder. Rice straw, bagasse, and some grasses are used in India for the production of strawboard. Wheat straw is also used to a limited extent. These raw materials are not available in sufficient quantities to work the strawboard mills to full capacity, with the result that there is a great disparity between the rated capacity of these mills and the production of strawboard. In order to enable the strawboard mills to use new fibrous raw materials, *Themeda arundinacea* (ulla grass) and *Vetiveria zizanoides* (panni grass), which are burnt every year to prevent fires in forests, were tested.

Themeda arundinacea (ulla grass). A number of digestions were carried out using lime. The quantity of lime was varied from 10 to 15%, the temperature of cooking from 140 to 162°C., and the period of cooking from 3 to 6 hours. The digestion of this grass with 15% lime on the weight of the air-dry raw materials in a concentration of 30 grams per liter at 140°C. for 6 hours was found to give pulp with the highest strength properties. The color of the pulp was suitable for strawboard. The yield of the pulp was 44.8% (on the weight of the raw material).

Freeness of the pulp	501 ml. (C.S.F.)
Thickness of the pulp sheet	0.028 in.
Basis weight	446.2 g./sq. m.
Breaking length	5516 m.
Burst factor (Mullen)	28.6

The pulp sheets were conditioned at 65% R. H. and 58°F. before testing.

Thus, *Themeda arundinacea* is a suitable raw material for the production of strawboard.

Vetiveria zizanoides (panni grass). The quantity of lime used with this grass was varied from 10 to 15%, the temperature of cooking from 140 to 162°C., and the period of cooking from 3 to 6 hours. The digestion of this grass with 10% lime on the weight of the air-dry raw material in a concentration of 20 grams per liter at 162°C. for 5 hours was found to give pulp with the highest strength properties under the conditions studied. The color of the pulp was suitable for strawboard. The yield of the pulp was 54.1% (on the weight of the raw material).

Freeness of the pulp	314 ml. (C.S.F.)
Thickness of the pulp sheet	0.0248 in.
Basis weight	412.2 g./sq. m.
Breaking length	4881 m.
Burst factor (Mullen)	19.6

The pulp sheets were conditioned at 65% R. H. and 58°F. before testing.

Vetiveria zizanoides is a suitable raw material for the production of strawboard.

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Phenol-Formaldehyde Resins for Wet-Strength Paper

High Resin Contents by the Beater Addition Process

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Data are presented for the increase in wet strength upon the beater addition of 1 to 25% phenolic-type resin with different fiber furnishes and the effect of resin treatment on dimensional stability of unbleached kraft stock.

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Wet-strength papers have been defined (*1*) as retaining a minimum of 15% strength in the wet state as compared to the dry condition. In commercial practice, the comparative wet versus dry figure may extend up to 35%. Papers possessing wet-strength within this range, when produced by the

beater or headbox addition of amino-type resins to the pulp slurry, are of considerable commercial importance for low-cost disposable applications such as paper bags, toweling, etc. The addition of 1 to 4% resin to the furnish produces wet strengths of the order of 15 to 35%. The factor limiting the magnitude of wet strength obtainable with the amino resins added at the beater or headbox is their difficulty of retention (*2*) especially on bleached pulps (*3, 4, 5*). Wet-strength stocks produced with resins of this type are extremely sensitive to moisture, heat, and dilute acids (*6*) which cause hydrolysis of the resin and consequent loss in wet strength. Dilute acid solutions at elevated temperatures dissociate the amino resins rapidly enough to permit reworking of cured broke or waste.

It is the purpose of the present paper to discuss the use of new phenol-formaldehyde-type resins (Synco 721, 730, and 421) in the production of permanent "super" wet-strength papers having wet versus dry strengths in the range 35 to 130%. This new magnitude in wet strength has been attained without sacrificing other important physical qualities and is economically feasible because of the excellent retention of the resin which is introduced without complicating papermaking operations.

The methods of application of these new resins are in many respects similar to those employed in the use of other wet-strength resins and size materials. This generality has previously been emphasized (*7*). Two different methods are employed, the choice being dictated by such circumstances as type of pulp, degree of hydration, amount of resin to be added, equipment, and flow-sheet considerations.

The first method is the direct process which is usually referred to as beater addition (*8, 9*). The resin is added to neutral stock in the beater or other batch mixer and precipitated upon the fiber by means of alum or alum-acid solutions. The procedure is identical with beater sizing with rosin solutions or emulsions.

The second process is the so-called inverted procedure which is usually called headbox addition. In this process the diluted resin is added to the stock continuously at some convenient point ahead of the forming wire. The stock is previously treated with alum or alum-acid in an amount sufficient to neutralize the resin and to adjust the final pH to a value ranging from 4.2 to 4.5. Specific details and instructions are obtainable, and the procedures will not be unduly elaborated here. It suffices to say that the introduction of these resins into paper stock in concentrations ranging from 1 to 60% is an uncomplicated and thoroughly commercial process.

Modifiers such as synthetic rubbers (Hycar, Neoprene, GRS types, etc.) have come into wide commercial use and these may be added together with the resin by either process. Elastomer concentrations up to 25% have been run commercially without difficulty and with high retention.

The very considerable increase in wet strength of papers produced by this process is accompanied by a smaller increase in dry strength, and appears to support the theory (*10*) that increase in wet strength is due primarily to increased adhesion between fibers, the ultimate fiber strength being only slightly increased. Significant increases in dry tensile and bursting strength are obtained as will be shown. Such gains in strength

Table I. Effect of 1, 3, 5, and 7% Resin Addition on Mixed Furnish Comprised of Equal Parts Asplund, Rag, and Waste (Inverted Procedure)

(Basis 24 × 36—500, 220 Lb.)

% Resin	Dry tensile M.D.	Dry tensile C.D.	Wet tensile M.D.	% Wet strength
0	15	7	1	6
1	15	9	4	25
3	15	10	9	60
5	25	18	20	80
7	38	25	36	96

are more likely to become large in papers or boards made from rough and poorly refined stocks.

The fact that such papers tend to be more "square," i.e., the differences in strengths across and with the machine direction are minimized, providing additional evidence in support of this theory. In order that improved adhesion between fibers be obtained, it is necessary that the wet-strength agent have greater adhesion to the fibers than is developed by the interfiber adhesion resulting from the dehyration of free-hydroxyl groups on adjacent fibers. While there is no general agreement regarding the possibility of chemical reaction of wet-strength resins with these hydroxyl groups (*11, 12*), nevertheless, in this circumstance this appears to be the case at least as regards a substantial portion of the resin furnished. For example, only part of the resin in the uncured stock may be solvent-extracted. A smaller proportion of the resin may be extracted by this means from well-hydrated stock than from less refined stock. The extracted paper still exhibits wet-strength properties and resists the action of dilute acids, etc., further indicating the presence of a considerable quantity of unextracted resin. No solvent has been found which will remove the resin in anything like a quantitative manner.

The following data were obtained from studies involving varied percentages of resin in combination with various types of straight fiber and mixed furnishes.

Table I values for 1, 3, and 5% resin inputs were obtained by testing directly off the machine. In addition to the high wet-strength values shown, the figures further demonstrate a definite "squaring" effect due to the resin.

The wet-strength values given in Table I for 7% resin input were derived from testing the paper after a short off-machine tower cure where the sheet came in contact with 350°F. air for a period of $1^1/_2$ minutes after which it was immersed in 70 to 75°F. water for 12 hours before testing. In all cases cited in this paper wet testing was carried out after immersion in 70 to 75°F. water for 12 hours and per cent wet strength calculated on the treated dry strength.

Whereas this paper is intended primarily to confine itself to a discussion of special wet-strength papers, there are, nevertheless some important corollary effects which should also be mentioned at this time. Some

Table II. Effect of 5% Resin Addition by Direct and Inverted Methods on Rope Broke Papers

% Resin	Cure at 300°F., min.	Bursting strength, pt. Dry	Bursting strength, pt. Wet	% Wet strength
0	5	18	2	..
5 (inverted)	5	15	10	66
5 (direct)	5	18	9	50

Table III. Effect of Coprecipitation of 4% Resin and 2% Neoprene on Light and Heavy Weight Kraft Papers

	Light weight paper		*Heavy weight paper*	
	Untreated	*Treated*	*Untreated*	*Treated*
Tear	20.85	18.69	81.12	72.15
Bursting strength	8.92	13.80	30.76	48.58
Tensile (dry)	7.64	10.28	23.29	30.75
Tensile (wet)[a]	0.958	4.31	3.169	23.22

[a] Wet tensiles were taken without additional curing after aging 2 weeks in an 80 to 85°F. room.

of these effects will be covered in more detail in later publications. The foregoing data have in each case been derived from testing machine-made papers. Further studies of these papers have clearly shown corollary effects due to the resin in addition to the abnormally high wet-strength values obtained. Among these should be mentioned comparatively permanent resistance to chemicals over a wide range of pH values plus good resistance to heat, aging, and oxidation as from outdoor exposure or contact with the soil. Good dimensional stability is gained and whereas it is not of as high an order as obtainable by off-machine saturation with water-soluble phenolics, nevertheless, the beater addition resin is preferred in many cases since it eliminates such disadvantages as: (1) embrittlement of cured sheet, (2) objectionable odor, (3) discoloration, and (4) two-step process.

Kraft paper treated with 25% resin has shown no breakdown after 6 months' exposure to the passage of hot oil. Citrus acids have no effect in loss of wet strength on papers containing 4 to 6% resin and although at the present time our test program is not completed there is evidence that certain papers treated with 15 to 35% resin have excellent resistance to fairly strong solutions (15 to 50%) of H_2SO_4 and HCl.

Maintenance of high wet-strength and other advantageous effects under alkaline operating conditions was clearly demonstrated in a test employing a 25% resin-treated paper as a filter media for hydrated lime slurry (Table IV).

The object of this test was to determine rate of filterability, cake discharge, clarity of filtrate, durability, effects of flexing by air blow at point of discharge of cake, blinding effects by solids, wet strength of media, and media life after constant range.

The tests were conducted on an Oliver 1 by 1, 25% submergence filter equipped with an Oliver automatic valve with $2^3/_4$-inch outlets and bridged for an air blow discharge. The following remarks are quoted from the test report:

"Preliminary tests were conducted with a slurry consisting of 32% hydrated lime and 68% water without the use of an air blow. Cake discharge of $^1/_{32}$-inch cake above the wire wrapping was accomplished as a smear, since the cake would not cut off. This test was run for $2^1/_2$ hours, and the cake discharge remained the same in quantity and condition. The filtrate was absolutely water white and free of solids.

Table IV. Effect of 20 and 25% Resin on a Mixed Furnish as Bleached Kraft and Linters (Direct Addition)

(Basis 20 × 26—500, 140 Lb. Wet Strength Calculated as Percentage of Treated Dry)

% Resin	*Cure at 300°F., min.*	*Bursting strength, pt.* *Dry*	*Wet*	*% Wet strength*
20	5	56	59	103.0
25	5	58	75	130.0

Table V. Effect of 12 and 20% Addition of Resin with Unbleached Kraft Pulp

(Expansion Percentages Are Given as Sum of Contraction from 50% R.H. to 5% and Expansion from 50% R.H. to 93%. 130-Lb. Ream Weight, 24 × 36—500)

% Resin	*Expansion, % M.D.*	*Expansion, % C.D.*
0	1.17	. . .
12	0.66	0.46
20	0.49	0.28

"Cake discharge was found to be excellent from this type media, although lime, being sticky, generally gives trouble in complete discharge from an ordinary fibrous media.

"Flow rates of tap water through the impregnated paper filter media after filtering hydrated lime for 23 hours. Media, filter, feed tank, pump, and piping were thoroughly cleaned before conducting tests.

"The media does not blind seriously although lime tends to blind ordinary filter media quite readily. Durability of media is unquestionably good for the period of time employed in tests. No effect was noted by the flexing of the media in the process of discharging the cake by means of an air blow. Since the overall tests entailed a period of 23 hours, the media was flexed or puffed approximately 460 times, still the media did not take on a permanent sag or bulge but retained its original tautness on the drum.

"Dry strength of the media is good as it does not break or crack when folded.

"Wet strength of the media is at least as good as dry since no damage was done by the constant flexing created by the air blow necessary to discharge the cake. Also no damage was noted by the wire wrappings across the media although a comparatively thin wire (0.049 inch) was employed."

Analogous to the high strength values determined by both tensile and bursting strength tests are the increased dry and wet scuff and abrasion resistances. Such an effect, in consideration of the fiber-bonding mechanism and data previously described, was to be expected. Wax pick is increased 7 to 10-fold by the addition of 5 to 10% of the resin to 130-pound unbleached kraft or hemp papers. Excellent fold values were obtained by coprecipitating 5% resin with 20% neoprene onto 75% kraft pulp. One such combination gave 44,000 M.I.T. double folds before failure.

Elongation is decreased by the addition of the resin. However, where greater elongation is required of the resin-treated papers coprecipitation with elastomer latices such as Hycar and neoprene is effective, the magnitude of the effect bearing direct relation to the ratio of rubber to resin.

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Received Feb. 22, 1951. Presented at the Annual Meeting of the Technical Association of The Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

ASSOCIATION NEWS AND EVENTS

TAPPI 1953 Annual Meeting

Arrangements have been made to hold the next Annual Meeting of the Technical Association of the Pulp and Paper Industry at the Commodore Hotel, New York, N. Y., on Feb. 16–19, 1953. All other Paper Week meetings will be held during the same week at the Waldorf.

Folding Box Conference

The TAPPI Lake Erie Section and the Technical Committee of the Folding Box Association of America will jointly sponsor a conference at the Carter Hotel, Cleveland, Ohio, on May 22–23, 1952. A feature of the meeting will be visits to folding box plants in the Cleveland area, including a visit to the Ohio Boxboard Co. mill at Rittman, Ohio. There will be an exhibit of machines used for quality and routine control tests.

The technical program will include papers on problems dealing with:

1. Folding Boxboard Manufacture
2. Folding Box Manufacture
3. Customer Specifications for Folding Boxes
4. Folding Box Use
5. Establishment of a Folding Box Quality Control Program
6. Using a Quality Control Program
7. Establishment of a Cooperative Effort Toward Technological Improvements in the Folding Box Industry
8. Other Needs of the Folding Box Industry

In addition there will be panel discussions. The membership of the panels will include representatives of a cross section of the industry to assure the discussions being as comprehensive as possible for all types and sizes of folding box plants.

All interested individuals are invited to attend the conference. Membership in TAPPI or the Folding Box Association will not be a requisite for attendance.

Reservations for the conference and hotel accommodations should be addressed to the TAPPI Lake Erie Section, 1200 West Ninth Street, Cleveland 13, Ohio.

Maine-New Hampshire Summer Meeting

The Maine-New Hampshire Section will hold its summer meeting at the Belgrade, Belgrade Lakes, Me., on June 20–21, 1952.

A business meeting and election of officers will be held on the morning of June 20.

The afternoon will be devoted to a series of papers on "The Problem of Obtaining Clean Stock."

On Friday evening, June 20 there will be a dinner and entertainment.

On Saturday morning the Brown Co. film "The Forest and the Woodsman" will be shown. Ladies are invited to this session. A talk will also be given on "The American Economic System."

TAPPI Division and Committee Chairmen

Kenneth P. Geohegan, President of the Technical Association, has made the following division and committee chairmanship appointments for the current year, ending in February, 1953:

ENGINEERING DIVISION—Charles J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y., *General Chairman*
Steam and Power Committee—H. Russell Arnold, Riegel-Caroline Pulp Co., Acme, N. C.
Materials Handling Committee—A. P. Schnyder, Ebasco Associates, Inc., New York, N. Y.
Drying and Ventilating Committee—M. L. Barker, Beckett Paper Co., Hamilton, Ohio.
Engineering Research and Machine Design Committee—John D. Lyall, Armstrong Cork Co., Lancaster, Pa.
Mill Design and Economic Aspects Committee—Roland A. Packard, National Production Authority, Washington, D. C.
Hydraulics Committee—Kenneth J. Mackenzie, Eastman Kodak Co., Rochester, N. Y.
Mill Maintenance and Materials Committee—Hubert F. Parker, New York and Pennsylvania Co., Lock Haven, Pa.
Electrical Engineering Committee—Ray Foster, Champion Paper & Fiber Co., Canton, N. C.
Chemical Engineering Committee—James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.
Data Sheets Committee—Henry J. Perry, *Paper Trade Journal*, New York, N. Y.
RESEARCH DEVELOPMENT DIVISION—Walter F. Holzer, Crown Zellerbach Corp., Camas, Wash., General Chairman.
Fundamental Research Committee—Harry F. Lewis, The Institute of Paper Chemistry, Appleton, Wis.
Statistics Committee—John F. Langmaid, Jr., S. D. Warren Co., Cumberland Mills, Me.
Microbiological Committee—R. F. De Long, Marathon Corp., Rothschild, Wis.
Patents Committee—Frank Makara, Patent Attorney, New York, N. Y.
INDUSTRIAL DIVISION—R. W. Kumler, American Cyanamid Co., New York, N. Y., General Chairman.
Cost Engineering Committee—A. E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt.
Vocational Education Committee (name to be changed to Training and Education Committee)—J. H. Groves, Union Bag & Paper Corp., Savannah, Ga.
Nonfibrous Raw Materials Committee—E. N. Poor, Hudson Pulp & Paper Co., Augusta, Me.
Water Committee—A. S. Erspamer, P. H. Glatfelter Co., Spring Grove, Pa.
Fibrous Agricultural Residue Committee—S. I. Aronovsky, Northern Regional Research Laboratory, Peoria, Ill.
Structural Fibrous Materials Committee—E. M. Jenkins, Johns-Manville Research Center, Manville, N. J.
CONVERTING AND CONSUMING DIVISION—Lewis K. Burnett, Ohio Boxboard Co., Rittman Ohio, General Chairman.
Corrugated Containers Committee—F. D. Long, Container Corp. of America, Chicago, Ill.
Graphic Arts Committee—F. D. Elliott, Time, Inc., Springdale, Conn.
Coating Committee—J. H. Heuer, Great Northern Paper Co., Millinocket, Me.
Wet Strength Committee—K. W. Britt, Scott Paper Co., Chester, Pa.
Plastics Committee—E. C. Jahn, College of Forestry, State University of New York, Syracuse, N. Y.
PULP MANUFACTURE DIVISION—K. O. Elderkin, Crossett Paper Mills, Crossett, Ark., General Chairman.
Acid Pulping Committee—J. M. McEwen, Weyerhaeuser Timber Co., Pulp Div., Everett, Wash.
Alkaline Pulping Committee—R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala.
Mechanical Pulping Committee—F. W. O'Neil, College of Forestry, State University of New York, Syracuse, N. Y.
Chemical Products Committee—Arthur Pollak, Consultant, New York, N. Y.
Paper Deinking Committee—J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.
Pulp Purification Committee—W. D. Harrison, Riegel Paper Co., Milford, N. J.
PAPER MANUFACTURE DIVISION—R. P. Price, Hammermill Paper Co., Erie, Pa.

Preparation of Papermaking Materials Committee—F. S. Klein, Byron Weston Co., Dalton, Mass.
Paper Making (Cylinder) Committee—J. J. Harrison, Michigan Carton Co., Battle Creek, Mich.
Paper Making (Fourdrinier) Committee—N. R. Phillips, Champion Paper & Fibre Co., Canton, N. C.
Testing Division—James d'A. Clark, Consultant, Longview, Wash.
Fibrous Materials Testing Committee—E. R. Schafer, Forest Products Laboratory, Madison, Wis.
Nonfibrous Materials Testing Committee—J. P. Casey, A. E. Staley Mfg. Co., Decatur, Ill.
Wax Testing Committee—(TAPPI-ASTM Joint Technical Committee on Petroleum Wax)—A. M. Heald, Scott Paper Co., Chester, Pa.
Pulp Testing Committee—Lorin V. Forman, Scott Paper Co., Chester, Pa.
Optical Properties Committee—Henry E. Obermanns, Hammermill Paper Co., Erie, Pa.
Microscopy Committee—C. E. Brandon, Howard Paper Mills, Inc., Dayton, Ohio.
Paper Testing Committee—Donald H. Newcomb, Riegel Paper Corp., Milford, N. J.
Container Testing Committee—C. H. Krebs, Atlas Boxmakers, Inc., Chicago, Ill.
Packaging Materials Testing Committee—Linton E. Simerl, Marathon Corp., Menasha, Wis.
Chemical Methods Committee—A. S. O'Brien, Eastman Kodak Co., Rochester, N. Y.
Standards Committee—Roger C. Griffin, Needham, Mass.
Research Appropriations Committee—John L. Parsons, Hollingsworth & Whitney Co., Waterville, Me.

Local Section Representatives

President Geohegan has appointed the following members of the Technical Association Executive Committee to be his representatives to the following local sections:

Maine-New Hampshire—George A. Day, Brown Co., Berlin, N. H.
New England—Milton Jacobs, Chas. T. Main, Inc., Boston, Mass.
Empire State—Ralph W. Kumler, American Cyanamid Co., New York, N. Y.
Delaware Valley—Ward D. Harrison, Riegel Paper Corp., Milford, N. J.
Kalamazoo Valley—William F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Ohio—K. P. Geohegan, Howard Paper Mills, Inc., Dayton, Ohio.
Lake States—Harry F. Lewis, The Institute of Paper Chemistry, Appleton, Wis.
Lake Erie—Lewis K. Burnett, Ohio Boxboard Co., Rittman, Ohio.
Chicago—William F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Pacific—Walter F. Holzer, Crown Zellerbach Paper Co., Camas, Wash.
Southeastern Pulp and Paper Society—James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

M.I.T. TAPPI Alumni

The TAPPI Alumni of the Massachusetts Institute of Technology met for luncheon at the Engineers Club in New York on Wednesday, February 20. John J. Healy, Jr., of the Monsanto Chemical Co., St. Louis, Mo., presided as Chairman.

The first M.I.T. luncheon took place in 1941 and it was through the efforts of R. G. Macdonald of TAPPI and the late Robert W. Van Kirk of Penick & Ford, Ltd., Chicago, Ill., that other members of the Alumni became interested and subsequently took an active part in making these luncheons a success. The chairmen of the M.I.T. TAPPI Alumni Group have been:

1941—R. G. Macdonald, TAPPI, New York, N. Y.
1942—Allen Abrams, Marathon Corp., Rothschild, Wis.
1943—John L. Parsons, Hollingsworth & Whitney, Waterville, Me.
1944—No luncheon.
1945—Saxton W. Fletcher, J. O. Ross Engineering Co., New York, N. Y.
1946—Robert W. Van Kirk, Penick & Ford, Ltd., Chicago, Ill.
1947—Herman T. Barker, Bird & Son, East Walpole, Mass.
1948—William A. Kirkpatrick, Allied Paper Mills, Kalamazoo, Mich.
1949—John Buss, Provincial Paper Ltd., Toronto, Ont.
1950—Lawrence W. Flett, National Aniline Div., Allied Chemical & Dye Corp., New York, N. Y.
1951—John B. Calkin, University of Maine, Orono, Me.
1952—John J. Healy, Jr., Monsanto Chemical Co., St. Louis, Mo.

As each year passed, the attendance continued to increase slowly. In 1952 there were 74 individuals present. The chairman elected for the 1953 luncheon was Kenneth J. Mackenzie, Eastman Kodak Co., Rochester, N. Y.

Until 1951 the luncheons consisted of general get-togethers, without formal speakers. The main feature was the introduction of those present. In 1951, a program was inaugurated that included a speaker and at that time Professor J. E. Vivian of M.I.T. described the Development Plan of the Institute. In 1952 Professor Warren K. Lewis of the Chemical Engineering staff of M.I.T. described the cooperation between the Institute and industry in research problems and set forth a basis on which the paper industry could also cooperate with the Institute in doing certain fundamental research.

Institute of Paper Chemistry Alumni

The Editor of *Tappi* requested each college alumni group that met during Paper Week to give him a report of the meeting and a history of the meetings held to date.

Harry F. Lewis, Dean of The Institute of Paper Chemistry, reported that the dinner meeting of the Institute Alumni was attended by about 100 former students and staff members on Monday evening, February 18. The men present represented 43 different paper companies in addition to a number from the Services and from Government-related agencies.

Statistical Conference

The Statistical Committee of TAPPI with the cooperation of the University of Maine will hold a conference on the application of statistical methods in the pulp and paper industry, Aug. 4–16, 1952 at the University of Maine, Orono, Me. The first week will be devoted to elementary studies; the second to advanced. Applications should be addressed to Professor S. H. Kimball at the university. The fees will include room and board for either a one or two weeks' attendance. A minimum group of 25 and a maximum of 40 is planned. Please send your application immediately to assist the committee in making arrangements.

LETTERS TO THE EDITOR

Evaluation of the Degree of Cooking

To the Editor of *Tappi:*

In the February, 1952, issue of *Tappi*, pages 99A–101A, in the article "Problems Related to the Degree of Cooking," by the writer I wish to report an error. On page 100A, left column, line 5, the table is erroneously headed "Oak Wood." The correct heading should be "Linden Wood."

Peter B. Borlew
Container Corp. of America
Fernandina, Fla.

HAS YOUR SAVE-ALL CAPACITY KEPT UP WITH YOUR PAPERMAKING CAPACITY?

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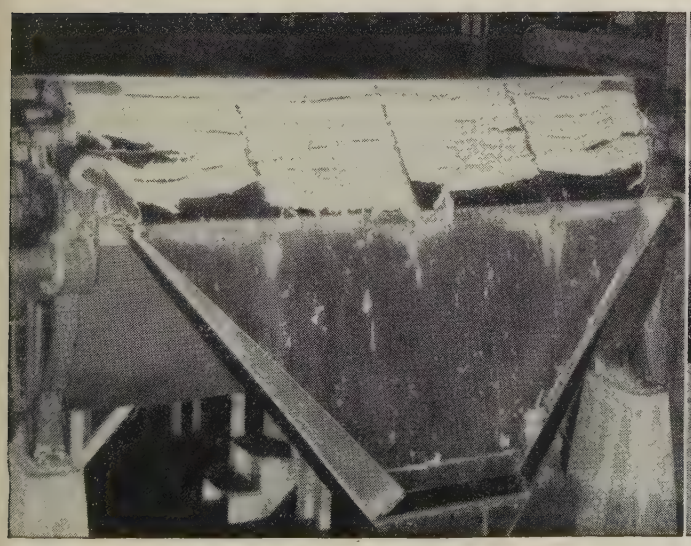
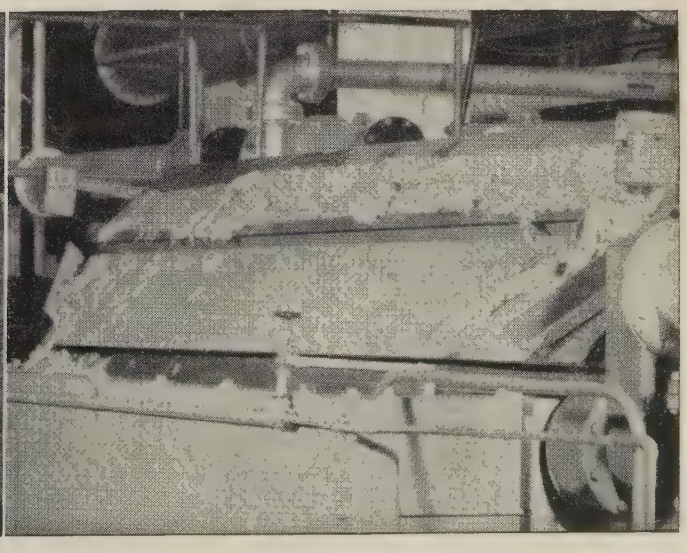




Thermal Decomposition of Chlorine Dioxide

To the Editor of *Tappi:*

In the February, 1952, issue of *Tappi* (Vol. 35, No. 2, pp. 75–80), in the article "Thermal Decomposition of Chlorine Dioxide," by the writer there are certain errors which should be pointed out

In Table IV, page 77. The last two columns should both be labeled "Initial ClO_2 Hydrolyzed, %." The fourth column then has the subheading "with agent" and the fifth column the subheading "without agent."

In Fig. 4, page 78, no symbol accompanies the words "Series F" in the caption, a half-blackened circle should have been shown.

RICHARD W. BROWN
Hammermill Paper Co.
Erie, Pa.

Detecting Slime in Pulp and Paper

To the Editor of *Tappi:*

In the July, 1951, issue of *Tappi* (Vol. 34, No. 7) there is an article (pages 302–305) "A New Method of Detecting Slime in Pulp and Paper," by Stanley J. Buckman and Virginia Henington. We are interested in trying this method but have been unable to obtain activol D.S. (Alkyl Naphthalene Sodium Sulphonate) from several chemical supply houses. Please advise.

R. E. BOWKER, *Chemist*
Chesapeake Corp. of Va.
West Point, Va.

To the Editor of *Tappi:*

We are sending to Mr. Bowker one of our standard 6-oz. bottles of Bulab slime indicator, together with instructions for use.

Over a period of about three months this indicator may discolor, if kept at room temperature in a colorless storage bottle. For this reason it is recommended that the standard supply bottle be kept for storage and transfer small amounts as needed to a dark-colored dropper bottle. If, at any time, it seems to have lost its effectiveness or is a lemon yellow in color, it should be discarded and a fresh supply obtained.

STANLEY J. BUCKMAN
Buckman Laboratories
Memphis, Tenn.

Oxidants That Promote the Dialdehyde Cleavage of Glycols, Starch, and Cellulose

To the Editor of *Tappi:*

This problem has been developed in an interesting way by L. J. Heidt, Edward K. Gladding, and C. B. Purves and presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry in New York, 1945 (*Paper Trade J.* 121, 9:35–43 (Aug. 30, 1945)).

The oxidation of glycols by periodate or lead tetraacetate is of great significance in organic and cellulose chemistry. The above authors have, however, left important parts of the problem unsolved. It is for this reason that the discussion of the problem is continued, in the hopes of finding a theory that will explain all the details of the subject.

Let me recapitulate, first, the primary principles in the theory of the above authors before offering a new explanation of the oxidation mechanism.

The result of the glycol cleavage is the oxidation of two hydroxyls simultaneously with the cleavage of the C—C bond, as a result of which two aldehyde groups form. The inner reaction mechanism is illustrated in Fig. 1. In A we have a glycol, in which the OH groups are represented by the two O atoms. They are in cis-position to one another, and hence about 3 A apart. B is a periodate complex with the heptavalent iodine, with four oxygen atoms nearly coplanar, i.e.,

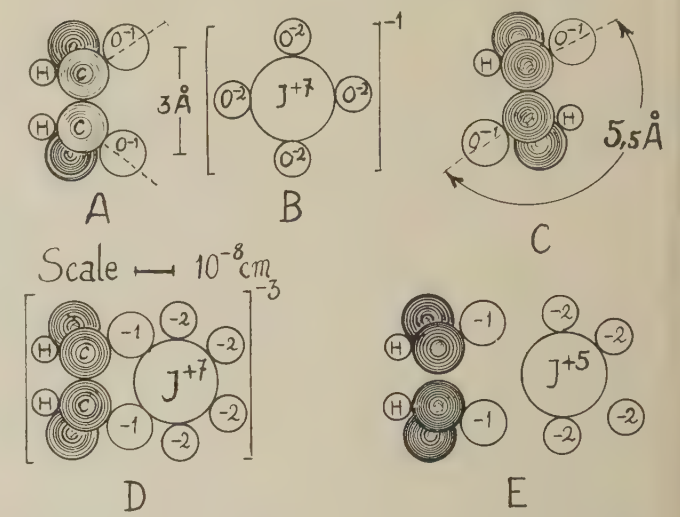


Fig. 1. A, cis-glycol; B, periodate complex (tetrahedral); C, trans-glycol; D, periodate-glycol-complex (octahedral); E, the complex decomposes

the iodine is at the center of a tetrahedron whose corners are occupied by the four oxygen atoms.

The main point of the theory is that the diameter of the iodine atom is also about 3 A, so that if the two hydroxylic oxygens of the glycol are to be coordinated in the iodine complex the latter must possess residual valencies suitably directed in space. This is illustrated in D. In the complex state the reactive molecules are so close to each other that electrons can pass over the connecting oxygen atoms.

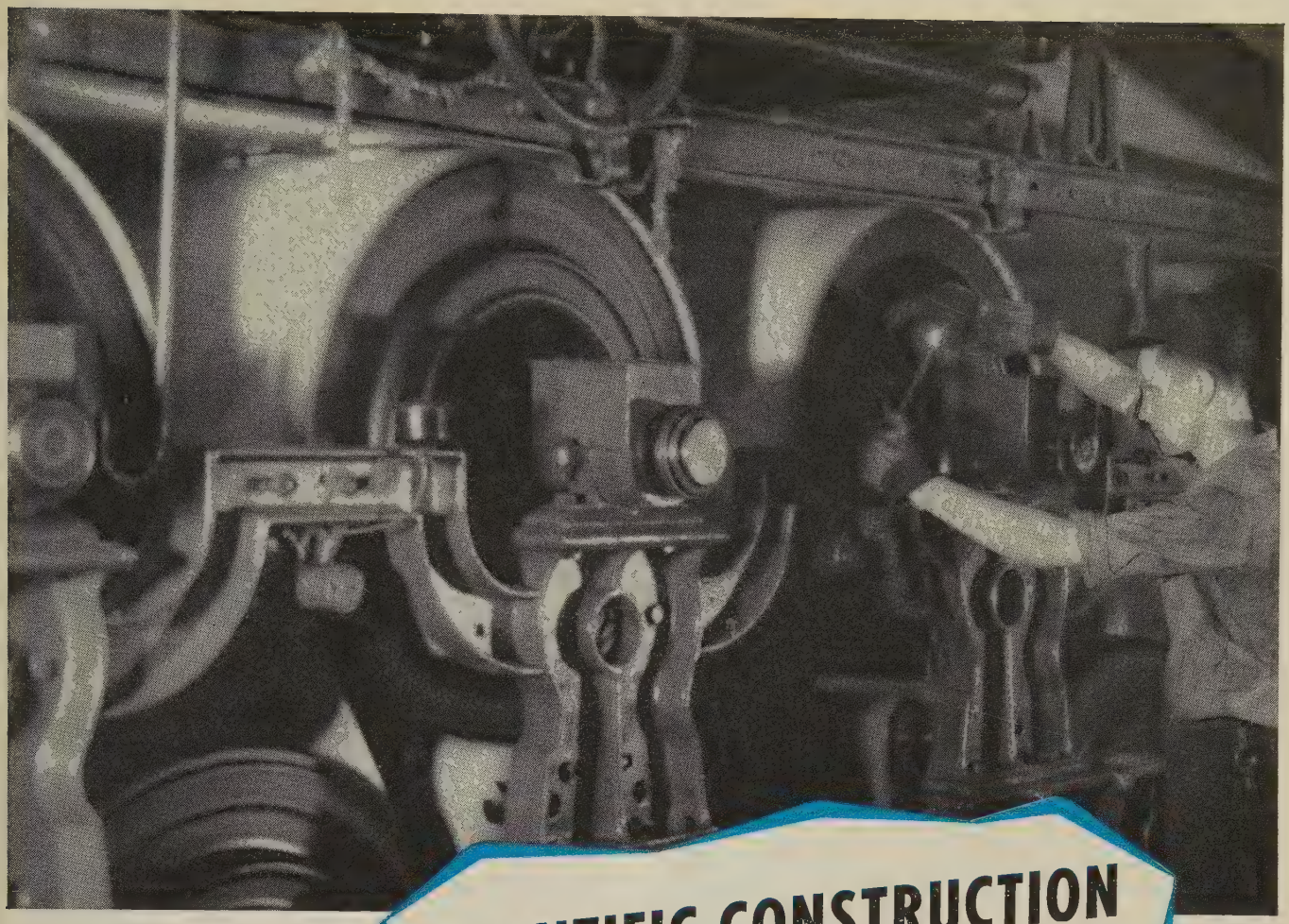
The decomposition of the glycol-periodate complex is obviously concerned with the ability of the iodine to annex an electron from each of the two glycol oxygen atoms. This ability must be a function of the oxidation potential of the iodine atom and the reducing potential of the glycol group. The annexation reduces the valence of the iodine from seven to five; the octahedral structure collapses, one oxygen atom combines with hydrogen ions to form water and the two glycol oxygens separate from the iodine, each minus one of the original electrons, to form the glycol free radical (E). Both of these oxygen atoms promptly make good their deficiency by sharing additional electrons derived from the adjacent carbon atoms, the additional oxygen-carbon covalent bonds form two carbonyl groups and the carbons in turn are compensated by the dissolution of the covalent bond between them.

The unsolved problems in this theory are:

1. The authors themselves admit that they have taken a longer iodine-ion-diameter than the known measured diameter for the heptavalent iodine. They have based the calculation on a diameter of about 3 A instead of 1 A. The diameters of the oxygen ions, on the other hand, are too short. They are about 1 A instead of 2.8 A.

2. The hydroxyl hydrogens of glycol are not taken into account in the reaction mechanism. It must be borne in mind that the moment the hydroxyl oxygens coordinate with the iodine atom the high positive charge (+7) forces the hydrogens deeper into the glycol instead of being drawn out toward the iodine complex in this dehydration reaction.

3. It is assumed that the iodine complex at first coordinates with four oxygen atoms only (i.e., in a tetrahedral structure), but at the moment of combination with the glycol change to an octahedral structure. No explanation is given as to why iodine prefers the alcohol oxygens as opposed to



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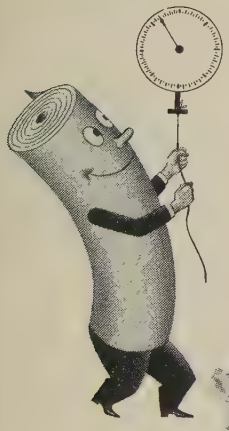

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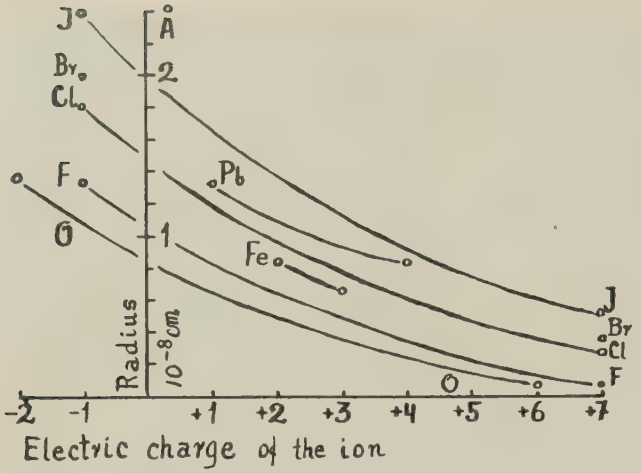

Fig. 2

the oxygen atoms of the solution (i.e., the water molecules).

4. The above authors give a theory of the oxidation of starch and cellulose. The theory presupposes that the hydroxyls are in cis-configuration and not in trans, but, it is known that in starch and cellulose the hydroxyls are in trans-configuration.

To explain these unsolved problems the present author has developed the following theory:

In the reaction mechanism the atoms appear with the radii determined by Goldschmidt, Pauling, and Zachariasen. These radii are for the different electric charges illustrated in Fig. 2.

The oxidation theory is demonstrated in Fig. 3. To the left is a glucose molecule with the atoms in covalent bondings. To the right is a periodate complex. In the center is a heptavalent iodine ion with a diameter of about 1 A, coordinated in octahedral structure with six bivalent oxygen ions with a diameter 2.8 A. Two of these ligands are oxygen and the other four OH groups. The total complex is thus univalent negative.

The energy state of the periodate complex causes an atom deformation of the oxygens in that the nuclei are repelled by the high charged iodine and, on the other hand, the electrons attracted. The influence is thus an *attraction of electrons combined with the formation of hydrogen bonds between the alcohol hydroxyls and the oxygen atoms in the periodate complex* which lacks the hydrogens. (See the figure at right).

The periodate first touches one of the hydroxyls of glucose and forms a hydrogen bond with it. The complex vibrates in that position until it finally also touches the other alcohol hydroxyl. At this moment the electron attraction acts from

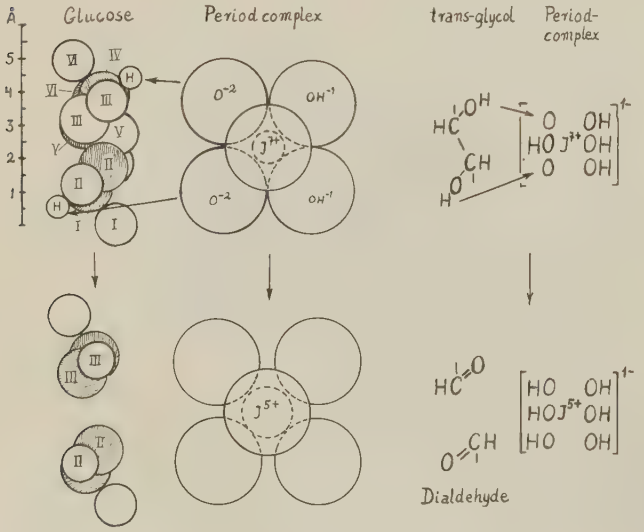

Fig. 3

two directions. This effect is great enough to deform the electron atmosphere in the glucose(or glycol) so much that it breaks at its center, that is between the two carbon atoms.

The electrons pass into the oxygen atoms of the complex, and these in turn give two electrons to the iodine. The electric charge falls from +7 to +5, which in turn reduces the deformation effect caused by the heptavalent ion. That is: the nuclei of the oxygen atoms draw nearer to the iodine and the electrons are repelled toward the peripheries. This in turn affects the hydrogen bonds attracting the hydrogen atoms, which now combine more closely with the oxygens of the iodine complex and leave the glucose. So the dialdehyde is formed.

This theory explains the possibility of the oxidation of trans-glycols to dialdehydes. The oxidation of cis-glycols, however, is more rapid as a consequence of the greater possibility of simultaneous contact with the two nearer alcohol hydroxyls.

The ion diameters in this explanation are the commonly accepted ones, and the heptavalent iodine coordinates in conformity with the common geometrical laws for complex substances, i.e., a central atom with a diameter of 1 A coordinates with six atoms with diameters of 2.8 A in octahedral structure and not in tetrahedral.

If my theory is accepted I must express my thanks to the authors Heidt, Gladding, and Purves for the inspiration they have given me—and, to the reader I would say that inspiration is generally worth more than the final realization of an idea.

Ruben von Konow
Technical University, Cellulose Dept., Helsinki, Finland

Prof. L. J. Heidt
Massachusetts Institute of Technology
Cambridge, Mass.

The enclosed correspondence is self-explanatory and needs little comment from me except the thought that you are much more competent to discuss Konow's points about our mechanism for the dialdehyde cleavage than I am. I would certainly be much obliged if you would send an answer to Mr. Macdonald. I myself see no disadvantage in publishing Dr. Konow's communication because we still have a lot to learn about the mechanism and any discussion is better than none.

Personally I am in doubt about the validity of his point 1, because we based our data on reference 23 (Helmholtz' values for ammonia trihydrogen paraperiodate, the nearest thing we could find to sodium paraperiodate).

His point 2 was covered by our tacit assumption that the hydrogen atoms from the glycol would be expelled into the solution as hydrogen ion, since the solution becomes more acidic.

His point 3 dealing with our assumption of a switch from the tetrahedral to the octahedral structure may be well taken, although our discussion is very cautious. My guess is that the periodate does not "prefer" glycol hydroxy groups to those of the solvent but distributes its attention according to the law of mass action.

Point 4 is covered by our comment that thermal agitation and free rotation about the C—C bond make our calculated distances between cis and trans hydroxy groups mere minimum and maximum values; also we say the approach to a transglycol is less probable (not impossible) and occurs at a much slower rate.

I don't know enough to discuss his alternative mechanism in detail but you do. My feeling is that, if there is anything constructive at all in Konow's approach, it is well worth publishing, even though it upsets some of our own ideas.

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McGill University, Montreal, Que.

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Allen W. Betz, Owner, Betz Engineering Sales Co., New Orleans, La., a 1937 graduate of Tulane University.

J. Alfred Bicknell, Research Chemist, S. D. Warren Co., Cumberland Mills, Me., a 1933 graduate of Worcester Polytechnic Institute.

Amiel W. Brinkley, Jr., Research Chemist, International Paper Co., Southern Kraft Div., Mobile, Ala., a 1950 graduate of Massachusetts Institute of Technology.

Luis A. Budd, Production Manager, C.I.C.S.S.A., Montevideo, Uruguay, a 1945 graduate of Buenos Aires University.

Laurence V. Burton, Executive Director, Packaging Institute, Inc., New York, N. Y., a 1911 graduate of the University of Illinois, with a Ph.D. degree from Yale University in 1917.

Harry D. Clarke, Manufacturing Representative, Black River Kraft Div., St. Regis Paper Co., New York, N. Y.

William H. Copeland, Pulpstone Technician, Norton Company of Canada Ltd., Hamilton, Ont., Canada, a 1936 graduate of McGill University, and a 1938 graduate of the University of Maine.

Chester D. Crowell, Jr., Student, New York State College of Forestry, Syracuse, N. Y.

Ellsworth L. Curtis, Assistant Superintendent, Chase Bag Co., Chagrin Falls, Ohio.

Edward S. Davis, Product Specialist, E. I. du Pont de Nemours & Co., Wilmington, Del., a 1936 graduate of Lehigh University.

Floyd Diephuis, Chemist, Hercules Powder Co., Brunswick, Ga., a 1941 graduate of Western Michigan College.

Millard R. Dusenbury, Shift Supervisor, Hercules Powder Co., Brunswick, Ga., a 1940 Graduate of Georgia Institute of Technology.

Terje Enkvist, Professor of Chemistry, University of Helsingfors, Helsingfors, Finland, a 1934 graduate of the University of Helsingfors with a Ph.D. degree.

August S. Gehrmann, Resident Engineer, Australian Paper Manufacturers Ltd., Petrie, Queensland, Australia, a 1935 graduate of the University of Queensland.

Johannes Goehring, Chief Engineer, Maschinenfabrik F.M. Voith, Heidenheim a. Brnez, Germany, a graduate of the Technical University.

Marie S. Goff, Librarian, Technical Library, E. I. du Pont de Nemours & Co., Wilmington, Del.

John P. Greiveldinger, Production Manager, Container Div., Robert Gair Co., Inc., New York, N. Y., a 1930 graduate of Bergen County Junior College.

Paul B. Hansen, Technical Director, Bergstrom Paper Co., Neenah, Wis., a 1937 graduate of the State College of Washington, with a Ph.D. degree from The Institute of Paper Chemistry.

Ralph S. Hartley, Physicist, Fiberboard Products, Inc., Research and Development Div., Antioch, Calif., a 1950 graduate of Reed College, Portland, Ore.

John G. Havighurst, Factory Manager, Cleveland Corrugated Box Co., Cleveland, Ohio, a 1940 graduate of Wesleyan University.

Herman H. Henkle, Librarian, The John Crerar Library, Chicago, Ill.

Alan C. Higgs, Manager, Colonial Sugar Refining Co. Ltd., Sydney, N.S.W., Australia, a 1932 graduate of Sydney University.

Erick I. Hoegberg, Librarian, American Cyanamid Co., Stamford, Conn., a 1938 graduate of Trinity College, Hartford, Conn.

Edward W. Hopper, Chief Chemical Engineer, Crucible Steel Co. of America, Pittsburgh, Pa., a 1923 graduate of Pratt Institute, and a 1932 graduate of Columbia University.

Lee Howard, Jr., Plant Engineer, Calcasieu Paper Co., Inc., Elizabeth, La., a 1947 graduate of Georgia Institute of Technology.

Charles D. Ingram, Technical Superintendent, Hollingsworth & Whitney Co., Mobile, Ala., a 1936 graduate of the University of Alabama.

James W. Jacokes, Manager, Chemical Laboratory, American Enka Corp., Enka, N. C., a 1936 graduate of Duke University with a Ph.D. degree.

Raymond L. Janes, Student, Western Michigan College, Kalamazoo, Mich.

William J. Johnson, Assistant Chief Engineer, Heaps, Waterous Ltd., New Westminster, B. C., Canada, a 1942 graduate of the University of British Columbia, with an M.Sc. degree in 1949.

Charles E. Kemp, Assistant Chemist, International Paper Co., Palmer, N. Y., a 1950 graduate of Rensselaer Polytechnic Institute.

Edward F. Kenney, Chief Chemist, U. S. Customs Laboratory, New York, N. Y., a 1922 graduate of the University of Maine.

Richmond Kerslake, Production Manager, Australian Paper Manufacturers Ltd., Matraville, N.S.W., Australia, a 1931 graduate of Sydney Technical College.

David J. Kraske, Student, Western Michigan College, Kalamazoo, Mich.

Ernest Kirschner, Manager, Niederrheinische Papier- und Pappenfabrik A.G., Neu B/Rhein, Germany.

Kenneth E. Lannert, Plant Engineer, Waxide Paper Co., St. Louis, Mo., a 1936 graduate of Washington University.

Daniel V. Lent, Instructor, State University of New York, College of Forestry, Syracuse, N. Y.

William A. Lunsford, Technical Service Engineer, Hercules Powder Co., Kalamazoo, Mich., a 1940 graduate of Miami University, with an M.S. degree in 1942 from Kansas State College.

Richard L. Maeder, Chemical Engineer, Robert Gair Co., Inc., Uncasville, Conn., a 1950 graduate of Queen's University, Canada.

Giuseppe Marri, Fratelli Marri S.R.L., Milan, Italy.

Charles T. Mauney, Secretary and Assistant Treasurer, Industrial Piping, Inc., Charlotte, N. C. Attended The Citadel.

Kenneth A. May, Draftsman, J. E. Sirrine Co., Greenville, S. C. Attended the University of Michigan.

James E. McCourt, Chemical Engineer, Crown Zellerbach Corp., Camas, Wash., a 1950 graduate of the University of Wisconsin.

James W. McCrum, Technical Superintendent, Australian Paper Manufacturers Ltd., Morwell, Vic., Australia, a 1929 graduate of the University of Melbourne.

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William A. Messervey, Assistant Division Engineer, Canadian General Electric Co. Ltd., Peterborough, Ont., Canada, a 1941 graduate of Dalhousie University.

Charles H. Mitson, Chief Chemist, Reg. N. Boxer Div., Canadian Wallpaper Mfrs. Ltd., New Toronto, Ont., Canada.

Benjamin C. Nash, Sales Dept., Nash Engineering Co., South Norwalk, Conn., a 1949 graduate of Rensselaer Polytechnic Institute.

Heinz Neuhoff, Chief Chemist, Feinpapierfabrik Felix Schoeller Jr., G.m.b.H., Osnabrueck, West Germany, a 1939 graduate of the University of Jena, Germany.

Forrest C. Palmer, Serials Librarian, D. H. Hill Library, North Carolina State College, Raleigh, N. C.

Walter P. Quinn, Manager, Container Corp. of America, Los Angeles, Calif. Attended Drexel Institute of Technology.

Henry A. Reid, Senior Investigation Chemist, Australian Paper Manufacturers Ltd., Melbourne, Australia, a 1936 graduate of Sydney Technical College.

A. William Riedel, President and Manager, Gus Riedel & Son, Kalamazoo, Mich. Attended Michigan State College.

E. S. Robinson, Vancouver Public Library, Main Library, Vancouver, B. C., Canada.

Oke Sandberg, Assistant Production Engineer, Self-Locking Carton Co., Palmer, Mass. Attended Upsala University.

Ernest Saunders, Pulp Mill Superintendent and Chief Chemist, The Mead Corp., Harriman, Tenn., a 1947 graduate of Virginia Polytechnic Institute.

Klaus H. Schenfelen, Managing Partner, Papierfabrik Scheufelen, Oberlennigen, Wuert., Germany, a 1937 graduate of the Technical University, Darmstadt.

Else L. Schulze, Technical Librarian, The Procter & Gamble Co., Ivorydale, Cincinnati, Ohio, a 1926 graduate of the University of Cincinnati.

Roy A. Secord, Technical Service Representative, E. I. du Pont de Nemours & Co., New York, N. Y. Attended Niagara University.

Leora E. Strake, Research Librarian, Goodyear Tire & Rubber Co., Akron, Ohio.

Louis E. Stratton, Chemical Engineer, Self-Locking Carton Co., Palmer, Mass., a 1940 graduate of Worcester Polytechnic Institute.

Henry F. Szepan, Sales Engineer, Improved Paper Machinery Corp., Nashua, N. H., a 1944 graduate of the University of New Hampshire.

Sidney F. Thune, Assistant Vice-President, National Starch Products, Inc., Chicago, Ill., a 1932 graduate of Worcester Polytechnic Institute.

James R. Upson, Instrument Supervisor, Union Bag & Paper Corp., Savannah, Ga.

Wally Z. Walters, Student, University of Cincinnati, Cincinnati, Ohio.

Robert E. Williams, Technical Adviser, New York & Pennsylvania Co., Lock Haven, Pa., a 1947 graduate of Lock Haven State Teachers College, and a 1950 graduate of Pennsylvania State College.

William F. Woodzicka, Project Engineer, Rhinelander Paper Co., Rhinelander, Wis., a 1950 graduate of the University of Wisconsin.

TAPPI Notes

Siegfried Aeschbacher, formerly of the Utzenstorf Paper Mill, is now Director of the Balsthal Paper Mill, Balsthal, Switzerland.

William H. Aiken, formerly of the Goodyear Tire & Rubber Co., is now Technical Director of Gardner Board & Carton Co., Middletown, Ohio.

Ellis T. Anderson is now Superintendent of the Multiwall Div., Fulton Bag & Cotton Mills, New Orleans, La.

David W. Baird, formerly of the Johns-Manville Research Center, is now Chemist for the New York & Pennsylvania Co., Lock Haven, Pa.

Arthur Biddle, formerly of the J. M. Fry Co., is now Chief Chemist for the Benj. C. Betner Co., Richmond, Va.

J. O. Boesinger has been transferred from Nashville, Tenn., to the Harriman, Tenn., mill of the Mead Corp. as Division Manager.

Walter J. Bublitz, formerly of the Munising Paper Co., is now in the Research Development Laboratory of the Kimberly-Clark Corp., Neenah, Wis.

Bernard W. Burgess, formerly of the Technical Section, Canadian Pulp and Paper Association, is now Assistant to the President of the Pulp and Paper Research Institute of Canada, Montreal, Que.

Lewis K. Burnett is now Manager of Production Control and Coordination, Ohio Boxboard Co., Rittman, Ohio.

Enrique Cabanes is now President of Industria de Papel, Carton y Envoses, S. A., Puentes Grandes, Havana, Cuba. This company recently changed its name from Primera Papelera Cubana.

John W. Crosson is now in charge of sales and purchasing for the Central National Corp., 100 Park Ave., New York, N. Y.

Robert Elias, formerly of the Whiting-Plover Paper Co., is now Associate Professor of Pulp and Paper Technology at Western Michigan College, Kalamazoo, Mich.

Philip Goldstein, formerly of Court Products, Inc., is now Technical Director of Bennett, Inc., Cambridge, Mass.

Karl M. Guest is now Assistant General Manager of the National Container Corp., Jacksonville, Fla.

William E. Hamilton has been transferred from Atlanta, Ga., to the Holyoke, Mass., office of the Hercules Powder Co. as Technical Service Engineer.

Robert W. Hisey, son of W. O. Hisey of the Sandy Hill Iron & Brass Works and now a student at Middlebury College, has been accepted as a student at The Institute of Paper Chemistry, Appleton, Wis., starting in September.

C. Harry Johnson is now Vice-President and General Superintendent of the Consolidated Paper Co., Monroe, Mich.

Charles M. Koon, formerly of the E.C.A., is now Supervisor of Technical Service for the Oxford Paper Co., Rumford, Me.

William A. Kosicki, formerly of the Marinette Paper Co., is now Chief Engineer for the Scott Paper Co., Chester, Pa.

Warren S. Kumblad has been transferred from Boston to the New York Office of Socony-Vacuum Oil Co. as Staff Engineer.

Richard H. Laftman, retired, formerly Vice-President of the National Container Corp., has returned from Sweden and is located at 1827 Stockton St., Jacksonville, Fla.

Lloyd Lang, formerly of the Green Bay Paper & Pulp Co., is now a Consultant, 521 North Broadway, De Pere, Wis.

Richard D. Lewis is now Chief Chemist for Finch, Pruyn & Co., Glens Falls, N. Y.

Heinz A. Lips is now Manager of the Lakes, Paper and Leather Section, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

David Y. Liversidge, formerly of Eaton-Dikeman Co., is now Research Chemist for the Mead Corp., Chillicothe, Ohio.

William D. Luker, formerly of the Union Bag & Paper Corp., is now a student at the University of Wisconsin, Madison, Wis.

John A. MacArthur, formerly of Stadler, Hurter & Co., is now Chief Engineer, Brompton Pulp & Paper Co., Montreal, Que., Canada.

Roscoe C. Masterman is now Paper Mill Superintendent, International Paper Co., Chisholm, Me.

John E. Newman, formerly of Esso Standard Oil Co., is now Manager of the Wax Dept., American Mineral Spirits Co., New York, N. Y.

Joseph P. Nugent is now Vice-President and Manager in Charge of Sales Engineering for the U. S. Wallboard Machinery Co., New York, N. Y.

Balancing

TIMBER RESOURCES WITH PRODUCTION REQUIREMENTS RESULTS IN A PERMANENT FOREST INDUSTRY

ONE OF the primary factors in the sustained production of forest products is the balancing of timber supply and plant production requirements. On the face of it, a simple enough statement; but in actual practice a highly integrated operation coordinating harvesting operations both in time and quantity with the production requirements of lumber, pulp, plywood and other types of plants and mills.

The Weyerhaeuser forestry policy is now being projected for the next 100 years. Tree farming, inaugurated in the United States by Weyerhaeuser in 1941, protects the timber from fire, bugs, and disease. Planned harvesting, including pre-logging, clean logging and re-logging, then directs and increases the utilization of the trees grown.

This farsighted forestry policy insures a continuing supply of pulpwood for the Weyerhaeuser sulphite and sulphate pulp mills.

Thomas E. Palmer, formerly of the St. Regis Paper Co., is now Sales Manager for the Courtilla Sales Co., Trenton, N. J.

William A. Robinson, formerly of Fibreboard Products, Inc., is now with the Hawaiian Sugar Planters Association, Waipahu, Hawaii.

Jorge R. Roldan, formerly of Cia. Industrial di Atenquique, is now Head of the Pulp and Paper Div., Aserraderos Gonzaliz Ugarte, S. A., Chihuahua, Mexico.

Joseph S. Scheuermann, Vice-President, and *Thomas N. Carter,* Director of Engineering, of the Winder Div. have resigned their positions with the Bagley & Sewall Co., Watertown, N. Y. Neither has any immediate plans for the future.

Alexander W. Tait, 316 Center St., Corinth, N. Y., has been granted a license to practice professional engineering in the State of New York.

B. M. Thomas, formerly of the Ohio Boxboard Co., is now Assistant to the President, Lowe Paper Co., Ridgefield, N. J.

Shu-Tung Tu, formerly Student of the University of Cincinnati, is now Chemist for the United Shoe Machinery Corp., Beverly, Mass.

David R. Wadleigh has been transferred from Chester, Pa., to the Soundview Div., of Scott Paper Co., Everett, Wash., as Project Engineer.

* * *

G. R. Kuhlman has succeeded *R. A. Monteith* as official corporate representative of Personal Products Corp., Milltown, N. J., in the Technical Association.

* * *

K. W. Peterson has succeeded *M. D. Shriver* as the official representative of the Bristol Co., Waterbury, Conn., in TAPPI.

Industry Notes

Newsprint producers of Canada plan to increase output by 914,000 tons to a total of 6,161,000 tons by 1960. Potential increase for the period is claimed to be 1,750,000 tons. These estimates do not include possible new entrants to the industry The ANPA report covered only 20 established producers who last year turned out 5,360,000 tons. One new producer in British Columbia is expected to produce 75,000–90,000 tons of newsprint this year.

* * *

The Defense Production Administration announced last week the following application approvals for certificates of tax amortization:

Bowater Paper Co., Inc., for a new newsprint mill in Charlestown, Tenn. Provides for a rapid tax write-off of 45%. $47,915,900 granted of $51,500,000.

West Tacoma Newsprint Co. at Steilacoom, Wash., was granted 45%. Amount approved was $4,474,000 of $5,000,000 requested.

Southland Paper Mills, Inc., at Lufkin, Tex., was approved for $15,040,000 which was the amount requested.

* * *

Snia Viscosa of Milan, Italy, has signed an agreement with the State Agency of National Finance of Mexico for the construction of a pulp mill in Chihuahua State. The plant is expected to have an estimated annual output of 40,000 tons, take two years to put into operation, and cost $15,000,000.

* * *

Press reports state that the Swedish Government is contemplating modifying its equalization fee on wood pulp exports to the United States, as well as Cuba, Mexico, and Venezuela. The purpose behind this proposed action is to encourage and increase wood pulp shipments to the United States to procure needed dollar exchange.

Swedish manufacturers of wood pulp will qualify only if they increase their shipments to the U. S. market, and after having made these larger shipments they make application to the Swedish Government for the removal of the export fee on specific wood pulp shipments. The Government action does not mean that the presently imposed export tax on pulp will be eliminated.

The present equalization fee is Sw. Kr. 200 (U. S. $'s 35) on Swedish wood pulp exported to the United States. About $11 of this tax goes direct to the Swedish Government as a duty on pulp exports, the remaining $24 is held in escrow by the Government to be returned to the wood pulp manufacturers at some future date, as yet undetermined.

* * *

American capital will be a substantial factor in financing Chile's first big newsprint mill, according to the Chilean Ministry of Economy. The mill, said to cost $10,000,000 will be capable of producing 50,000 tons of high-grade newsprint annually at substantially lower manufacturing costs than in the United States or Canada.

* * *

Plans have been announced for the construction of a 200-ton daily capacity pulp mill at Nelson, B. C. In addition, a forest tract of 400,000 acres will be developed, including 40,000 acres in the Lardeau Valley, northeast of Nelson. A new company, Kootenay Forest Products, Ltd., a subsidiary of Glacier Lumber Co. of Nelson, has been formed to build the mill.

* * *

The United States, with but 6% of the world's population now consumes 68% of the world's paper and paperboard production. It produces 58% of the world's supply. Next highest producer is Canada, with an output in 1951 of 9,600,000 tons.

The expected 1952 increase in capacity is as follows: paper —532,890 tons; paperboard—662,780 tons; wood pulp—1,016,647 tons.

* * *

Expenditures by the paper industry for new plants and equipment in the first quarter of this year are expected to reach 13 million dollars, compared with 140 million dollars in the final quarter of 1951, according to the Securities and Exchange Commission.

* * *

The Secretary of Commerce has issued a revised list of essential activities. The production of pulp, paper, and paper products is eighth on the list.

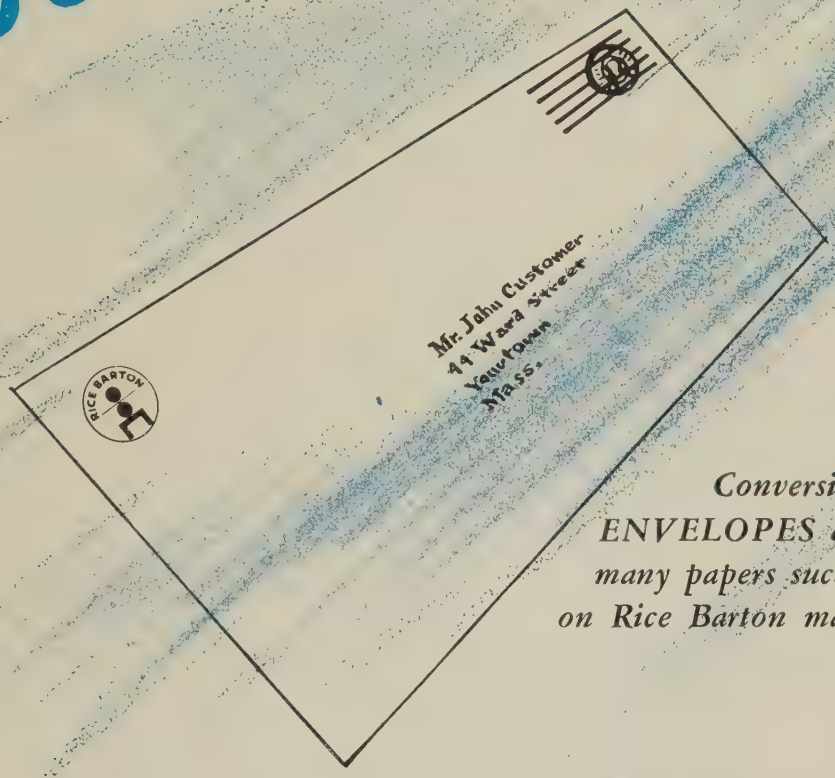
Manufacturers of cardboard, paperboard, and paper made from waste paper believe that the industry's business outlook for 1952 is a reasonably optimistic one. All grades of waste paper are in fair-to-good supply. Most mills in the industry are running up to 85% capacity and the quality of the waste paper has improved since 1951. Although the industry can produce 13 million tons, the 1952 production is expected to be 11,500,000 tons. This drop is due primarily to decreased use of paperboards for packaging purposes.

Manufacturers report losses in paper made from waste. They cite impurities caused by inks used for identification and by adhesive resins used in cardboard or paperboard boxes for binding purposes. These problems are being studied by TAPPI, printers and publishers, waste paper dealers, and The Institute of Paper Chemistry.

* * *

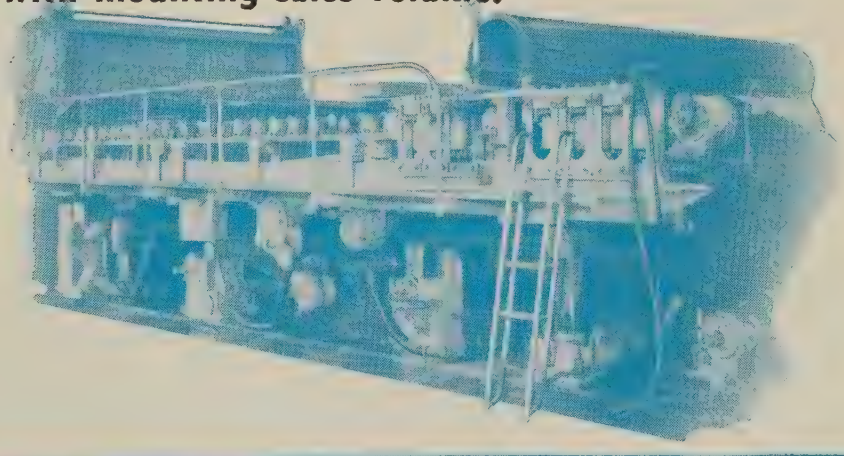
A total of 800,000 trees are being distributed this Spring to landowners in three central Wisconsin counties by the Nekoosa-Edwards Paper Co., Port Edwards, Wis. The program started in 1949 when 150,000 trees were distributed. By the end of 1952 more than two million trees will have been

Good News Travels Fast!



Conversion papers for ENVELOPES are among the many papers successfully made on Rice Barton machines.

Rice Barton machines are good news to any production department. With them, production schedules can keep pace with mounting sales volume.



RICE BARTON

RB4-52

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given out in this manner. The species include Norway pine and jack pine seedlings. The tree planting program has proved helpful to farmers in establishing windbreaks, erosion control, and for wood-lot planting.

* * *

M. W. Smith is now Director of the Forest Products Div., O.P.S. M. C. Walsh is Assistant Director and C. E. Carpenter, formerly of the Ohio Boxboard Co., is Assistant Chief of the Pulp, Paper, and Paperboard Branch.

* * *

Olin Industries, Inc., have made the following appointments within its Research and Development Dept. at New Haven, Conn.: Charles H. Hofrichter, Jr.—Research Section Chief: William E. Mydans—Evaluation of Marketable Values of Film Properties; Fred H. Olson—Packaging Development; S. Jackson Wommack, Jr.—Fiber Development Section Chief; and Michael Karelitz—Chief of the Engineering Section.

* * *

About 44% of the total newspaper circulation is in the Eastern seaboard states, and 47% of the total Sunday circulation is in these states. In seven cities in these states—New York, Boston, Philadelphia, Washington, Pittsburgh, Baltimore, and Newark, the combined circulation of the newspapers represents about one fourth of the national total of dailies and one third of the national total of Sunday newspapers.

* * *

The Fifth National Public Health Engineering Conference will be held at the University of Florida, Gainesville, Fla., on May 20–21, 1952. Among the subjects to be discussed will be "Progress in Disposal Methods of Pulp and Paper Mill Wastes."

* * *

Rayonier, Inc., announced plans for the early construction of a pulp mill at Doctortown, Ga. It will cost approximately $25,000,000 to build and will be capable of producing 250 tons a day of purified wood cellulose.

A mill site of 530 acres has been purchased and construction will start as soon as steel and other materials requiring Government allocation are available.

Approximately 450 people will be employed to work in the mill itself, and another 400 to 500 persons will work in the cutting and transportation of pulpwood.

The mill will use an improved process which permits the production of superior grades of wood cellulose, primarily for high tenacity yarn applications, such as tire cord, parachute materials, and rubber belting. Flexibility is provided in the mill's design, however, so that it will also be able to produce nitration pulp if necessary for the manufacture of explosives, as well as pulps for special types of paper and for standard textile yarns.

To provide an assured long-term supply of raw materials for this new operation, Rayonier has recently enlarged its already substantial wood resources in the South which had been built up to support production at the Fernandina Div. in Florida. Large acreages have been purchased this year, and now the company owns or controls approximately 400,000 acres in southeastern counties of Georgia and northeastern counties of Florida.

The Doctortown project will be carried out under the executive direction of R. F. Erickson, Vice-President in Charge of Engineering and Plant Development. The mill's special processing procedures were developed by Rayonier's Research Div. under the supervision of A. N. Parett, Vice-President in Charge of Research and Development. Designs for the installation of the processing equipment have been prepared by Rayonier's own engineers, and Ebasco Services, Inc., has been retained as consulting engineers to design the mill structurally.

* * *

Nearly a half-million acres of land in the United States were planted to trees in 1951. Of this planting, 79% was on privately owned land. The 1951 reforested area of 456,368 acres raises the total planted area to date to 7,692,697 acres. The U. S. Forest Service estimates that about 62 million acres in the United States are still in need of planting. State nurseries in 20 states reported a demand for 60 million trees in excess of the available supply. To meet this demand 7 states are developing new nurseries and 12 are expanding existing nurseries.

The American Forest Products Industries, 1319 Eighteenth Street, N. W., Washington, D. C., has issued a 16-page bulletin on "Measuring a Decade of Papers."

James L. Madden, President of Hollingsworth & Whitney Co., is President of the A.F.P.I. Sydney Ferguson, President of the Mead Corp., is a past-president.

* * *

The Armstrong Forest Co. of Johnsonburg, Pa., has purchased patent rights for chemical girdling of trees from Alexander R. White of Port Arthur, Ont. (U. S. pat. 2,324,968, July 20, 1943). According to the purchase agreement, the Armstrong Forest Co. has dedicated the chemical girdling process to public use. Through the use of sodium arsenite solution painted on a bark girdle, selected trees are killed on the stump. The bark on treated trees loosens in from three to seven months. Use of chemical girdling extends the bark peeling season, making pulpwood a year-around tree farm crop.

* * *

At the monthly meeting of the Breakfast Club of the Springfield Chamber of Commerce on February 6, the Strathmore Paper Co. of West Springfield, Mass., was honored in recognition of the 60th anniversary of its founding. Strathmore was given its original charter of incorporation on Feb. 18, 1892. Strathmore's original charter was issued to it as the Mittineague Paper Co. Erection of the Company's first mill was begun on March 17, 1892. In 1911 the Mittineague Paper Co. was merged with the Woronoco, Mass. (under the same ownership) to form the Strathmore Paper Co.

* * *

The iron and steel scrap drive in Western Massachusetts has received substantial help by tonnage turned in by paper mills in the Springfield area. Nine mills from Berkshire, Franklin, Hampden, and Hampshire Counties have collected and delivered 500 tons of dormant iron and steel scrap over a period of four months. This is an unusual record for a small community that does not generate iron and steel scrap in its manufacturing processes. Large amounts of copper and brass were also collected.

* * *

The Third International Paper and Allied Trades Exhibition will be held on Oct. 23–31, 1952, at the Parc des Expositions, Porte der Versailles, Paris, France.

* * *

The Weyerhaeuser Timber Co. is expanding its pulp and papermaking plant at Springfield, Ore. Production of kraft pulp will be increased from 250 to 375 tons per day.

* * *

In "Today It's Different," the house organ of the Everett Pulp & Paper Co., Everett, Wash., lithography is featured in the March issue.

Mark of Excellence...

FOR **100** YEARS

Many, many years ago Adolphus Busch, co-founder of Anheuser-Busch, defined the reason for his company's growing success and reputation . . . "Making Friends is Our Business." Today, celebrating our 100th Anniversary, Anheuser-Busch still keeps faith with that same principle in all the phases of our business: Top quality for all Anheuser-Busch products . . . wholehearted, sincere service to our customers . . . and a continuous program of research and development to seek even better things for all the industries the company serves.

Corn Products Department

ANHEUSER-BUSCH, INC. . . . ST. LOUIS

CORN STARCHES, DEXTRINES, GUMS & CORN SYRUPS

FOR THE PAPER INDUSTRY

United States Imports of Wood Pulp (in Short Tons)

Receipts of Wood Pulp from Europe by Country of Origin

	Sweden	Finland	Norway	Russia	Austria	Italy	Czecho-slovakia	France	Germany	Switzer-land	Denmark	Total
1946	445,114	115,220	0	0	0	0	0	0	0	0	0	560,334
1947	555,215	223,973	9,577	4928	0	0	0	0	0	0	0	793,693
1948	384,576	175,900	13,218	0	1,696	0	0	0	0	0	0	575,390
1949	265,621	148,903	29,208	0	4,459	0	1027	0	0	0	0	449,218
1950	398,814	205,651	28,958	9773	21,005	167	2597	115	977	89	0	668,146
1951	257,061	182,616	36,365	0	3,225	0	512	106	2812	89	15	482,801

United States Imports of North American Wood Pulp (in Short Tons)

Includes: Canada, Newfoundland, Labrador, Mexico

	Bleached sulphite					Groundwood				
	Paper grades	Nonpaper grades	Unbleached sulphite	Bleached sulphate	Unbleached sulphate	Bleached	Unbleached	Soda	Screenings	Total
1946	195,112	189,775	411,512	56,213	137,472	..	220,823	19,740	14,484	1,245,131
1947	229,771	224,882	438,552	174,966	145,626	..	279,512	21,203	14,255	1,528,767
1948	247,838	224,942	453,674	212,022	149,787	..	274,787	24,843	12,828	1,600,721
1949	241,280	149,801	256,993	323,212	117,917	538	188,620	27,315	7,649	1,313,325
1950	288,014	229,092	364,531	366,047	183,238	15,548	228,627	33,947	7,991	1,717,035
1951	258,571	225,836	441,235	450,076	176,837	17,054	264,996	33,373	13,141	1,881,119

United States Imports of European Wood Pulp (in Short Tons)

	Bleached Sulphite					Groundwood			
	Paper grades	Nonpaper grades	Unbleached sulphite	Bleached sulphate	Unbleached sulphate	Bleached	Unbleached	Screenings	Total
1946	27,541	12,417	207,059	23,484	260,434	..	29,399	..	560,334
1947	58,788	23,724	293,096	64,103	324,548	..	29,434	..	793,693
1948	74,992	10,539	221,033	65,967	186,662	..	16,197	..	575,390
1949	90,008	4,145	135,229	68,397	130,897	..	19,065	1477	449,218
1950	115,020	8,262	163,975	86,548	257,160	556	34,162	2463	668,146
1951	90,991	3,805	121,630	71,055	158,722	162	34,754	1682	482,801

United States Imports of Wood Pulp—by Country of Origin (in Short Tons)

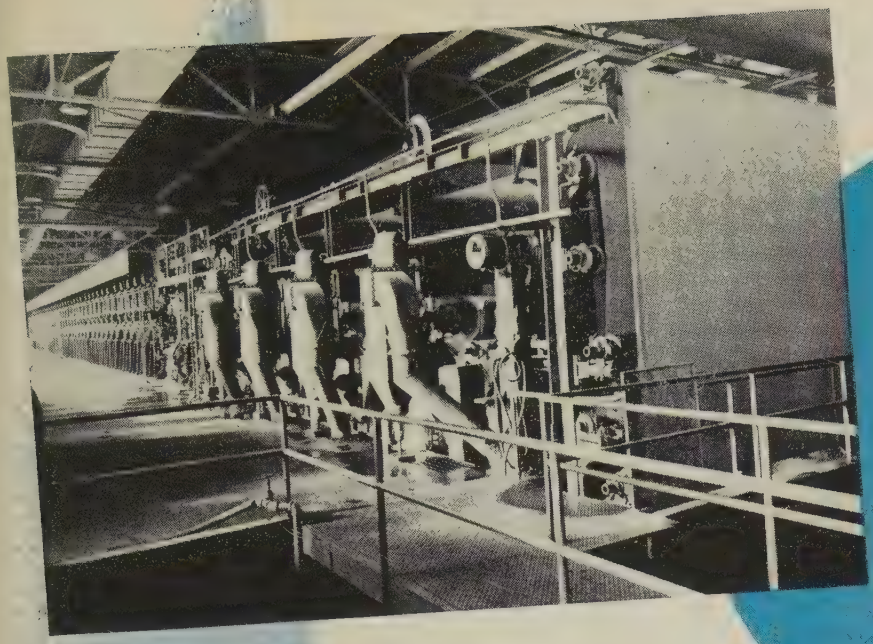
January 1952

Grade	Total	Canada	Sweden	Finland	Norway	Germany
Sulphite	89,812	75,018	4,449	9,303	873	169
Rayon and spec.	20,410	20,292	118	..	..	..
Other bleached	21,648	19,035	750	990	873	..
Unbleached	47,754	35,691	3,581	8,313	..	169
Sulphate	65,418	50,051	10,740	4,627	..	..
Bleached	43,560	37,292	6,268	..	..	..
Unbleached	21,858	12,759	4,472	4,627	..	..
Soda	2,273	2,273	..	..	..	..
Groundwood	17,892	17,503	..	389	..	..
Bleached	1,956	1,956	..	..	..	..
Unbleached	15,936	15,547	..	389	..	..
Screenings	963	963	..	..	..	..
Chemical	566	566	..	..	..	..
Mechanical	397	397	..	..	..	..
Total	176,358	145,808	15,189	14,319	873	169

Source: Bureau of the Census

Estimated Apparent World Paper Consumption in 1950

Continent	Production, short tons	Imports, short tons	Exports, short tons	Apparent consumption, short tons	Population,[a] 1000s	Pounds/capita	
						Current report	1949 report
North America	31,112,213	5,130,002	5,504,673	30,737,542	165,534	371.37	349.67
Central and South America	707,188	633,126	809	1,339,505	156,817	17,08	16.54
Northern Europe	2,694,575	12,917	1,978,572	728,920	14,310	101.87	115.53
Continental Europe	10,727,288	1,661,831	1,078,344	11,310,775	532,586	42.47	48.51
Africa	80,114	349,304	2,976	426,442	131,863	6.47	5.14
Near East	20,410	68,929	4,964	84,375	62,621	2.69	2.64
Asia	1,376,463	540,801	22,605	1,894,659	1,139,336	3.33	2.41
Australasia	237,213	146,344	2,616	380,941	10,134	75.18	98.49
World	46,955,464	8,543,254	8,595,559	46,903,159	2,213,201	42.38	42.62
North America							
United States*	24,300,178	5,007,379	372,734	28,934,823	151,689	381.50	358.12
Canada and Newfoundland*	6,812,035	122,623	5,131,939	1,802,719	13,845	260.41	256.02
Total	31,112,213	5,130,002	5,504,673	30,737,542	165,534	371.37	349.67



Alton's No. 3 machine, world's record strawboard producer. Photo courtesy of Alton Box Board Company, Alton, Illinois.

Nalco 3-WAY SERVICE at Alton Box Board Company

HERE are the three water treatment services performed by Nalco at Alton Box Board Company, Alton, Illinois. In addition, experimental work on process waters using Nalco anti-foam chemicals is now being done at Alton:

1. **SLIME CONTROL** chemicals, fitted to Alton Box Board requirements, help maintain high quality . . . prevent slime spots and breaks due to slime.

2. **CLARIFICATION** of mill water with Nalco #680 Sodium Aluminate . . . A versatile chemical also used widely for size control and maximum alum availability.

3. **BOILER WATER TREATMENT** with specially-processed organic chemicals for use in high-capacity, high-pressure boilers.

Use of Nalco Chemicals and Services at Alton Box Board Company shows clearly the wide extent to which good water treatment, properly applied, can be utilized to make over-all mill operation cleaner, more efficient and more economical.

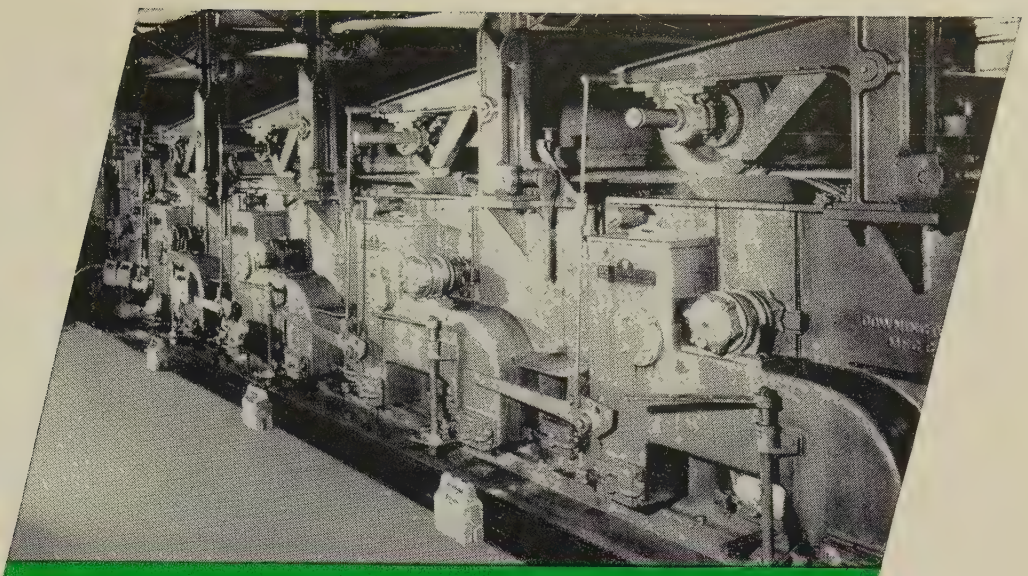
The Nalco System can be applied selectively, or for complete water treatment protection in *your* mill. Write today for full details on your specific water treatment problems.

NATIONAL ALUMINATE CORPORATION
6197 West 66th Place
Chicago 38, Illinois
Canadian inquiries should be addressed to Alchem Limited, Burlington, Ontario

THE Nalco SYSTEM • **Serving the Paper Industry through Practical Applied Science**

Estimated Apparent World Paper Consumption in 1950 (*continued*)

Continent	Production, short tons	Imports, short tons	Exports, short tons	Apparent consumption short tons	Population,[a] 1000s	Pounds/capita Current report	Pounds/capita 1949 report
Central and South America							
Argentina*	170,857[c]	215,830	220	386,467	17,196	44.94	45.38
Bolivia	800	3,161	...	3,961	3,990	1.99	1.70
Brazil	238,696	58,907	...	297,603	50,900	11.69	12.88
British West Indies[b]	...	7,199	...	7,199	1,327	10.85	10.85
Chile	52,170	19,093	56	71,207	5,916	24.07	25.12
Colombia*	6,134[c]	45,559	...	51,693	11,266	9.18	7.38
Costa Rica*	...	4,052	...	4,052	851	9.52	16.91
Cuba*	37,217	105,456	...	142,673	5,308	53.76	36.95
Dominican Republic	...	2,759	...	2,759	2,121	2.60	2.56
Ecuador*	331[c]	11,966	...	12,297	3,077	7.99	4.01
El Salvador	n.a.	3,823[d]	...	3,823	1,859	4.11	4.12
Guatemala*	200[c]	5,537	...	5,737	2,803	4.09	1.88
Haiti	...	1,102	...	1,102	3,112	.71	.63
Honduras	...	1,797	...	1,797	1,534	2.34	3.00
Jamaica	...	6,063[c]	...	6,063	1,403	8.64	9.27
Mexico*	149,930	59,079	...	209,009	25,000	16.72	17.07
Netherlands West Indies	...	1,556	25[e]	1,531	149	20.55	11.66
Nicaragua	...	1,624	...	1,624	1,053	3.08	3.88
Panama*	...	7,478	...	7,478	802	18.65	18.41
Paraguay	463	1,852	...	2,315	1,406	3.29	1.84
Peru*	17,659	13,934[d]	378[d]	31,215	8,405	7.43	8.31
Uruguay*	22,865	30,797	130	53,532	2,353	45.50	35.20
Venezuela*	9,866	24,502	...	34,368	4,986	13.80	13.53
Total	707,188	633,126	809	1,339,505	156,817	17.08	16.54
Northern Europe							
Norway*	530,350	2,580	358,280	174,650	3,281	106.46	119.81
Sweden*	1,300,705	8,202	954,004	354,903	7,017	101.16	121.56
Finland*	863,520	2,135	666,288[f]	199,367	4,012	99.39	101.51
Total	2,694,575	12,917	1,978,572	728,920	14,310	101.87	115.33
Continental Europe							
Austria*	373,520	6,526	132,918	247,128	6,881	71.83	43.18
Belgium	327,974	117,344	37,614	407,704	8,651	94.26	127.43
Bulgaria	24,251[c]	32,368[d]	...	56,619	7,160	15.81	8.53
Canary Islands[b]	...	2,220	...	2,220	564	7.87	7.87
Czechoslovakia	238,791	2,750	2,542	238,999	12,463	38.35	52.30
Denmark*	115,035	170,330	4,992	280,373	4,279	131.04	95.34
Eire*	22,046[c]	66,834	5,242	83,638	3,006	55.65	40.88
France*	1,450,670	33,587	161,266	1,322,991	41,900	63.15	73.72
Germany, Western	1,725,145	104,713	64,291	1,765,567	48,129	73.37	31.38
Greece*	38,883	22,824	4	61,703	7,960	15.51	9.57
Hungary	59,072[d]	6,678[d]	...	65,750	9,205	14.29	14.00
Iceland	...	7,856	...	7,856	143	109.87	27.68
Italy*	592,544	44,567	25,075	612,036	46,272	26.45	27.68
Netherlands*	696,120	145,436	298,344	543,212	10,027	108.35	88.32
Poland	292,330	49,477[d]	28,847[d]	312,960	24,977	25.06	21.99
Portugal*	45,590	13,665	797	58,458	8,490	13.77	14.32
Rumania[b]	55,997	n.a.	1,991	54,006	15,873	6.80	6.80
Russia*	1,312,509	n.a.	n.a.	1,312,509	193,000	13.60	..
Spain*	187,131[d]	75,656	6,801	255,986	28,287	18.10	14.58
Switzerland*	242,000	8,600	4,100	246,500	4,703	104.82	97.04
United Kingdom*	2,927,680	750,400	303,520	3,374,560	50,616	133.33	102.01
Total	10,727,288	1,661,831	1,078,344	11,310,775	532,586	42.47	48.51
Africa							
Algeria*	13,329	37,588	1,932[d]	48,985	8,330	11.76	8.15
Belgian Congo*	...	3,597	...	3,597	11,259	0.64	1.02
British East Africa	...	4,228[c]	...	4,228	11,330	0.37	2.09
Egypt*	19,290[c]	65,913	666	84,537	20,439	8.27	10.05
French Cameroon*	...	773	...	773	3,006	0.51	..
French Morocco*	6,172[c]	21,605	...	27,777	8,617	6.45	1.36
French Equatorial Africa*	...	1,222	...	1,222	4,004	0.61	0.56
French West Africa*	...	6,490	...	6,490	15,831	0.82	
Kenya, Uganda, and Tanganyika*	...	11,226	...	11,226	18,409	1.22	0.51
Madagascar*	...	1,842	...	1,842	4,207	0.88	0.79
Mozambique[b]	...	824	...	824	6,116	0.27	0.27
Reunion*	...	465	...	465	242	3.84	..
Southern Rhodesia	...	5,214	67	5,147	2,022	5.09	1.59
Spanish Morocco	1,323[c]	1,055	311[e]	2,067	1,082	3.82	4.85
Tangier	...	1,178	...	1,178	111	2.12	..
Togoland*	...	171	...	171	982	0.35	..
Tunisia*	...	10,361	...	10,361	3,231	6.41	2.45
Union of South Africa	40,000	175,552	n.a.	215,552	12,645	36.73	13.09
Total	80,114	349,304	2,976	426,442	131,863	6.47	5.14



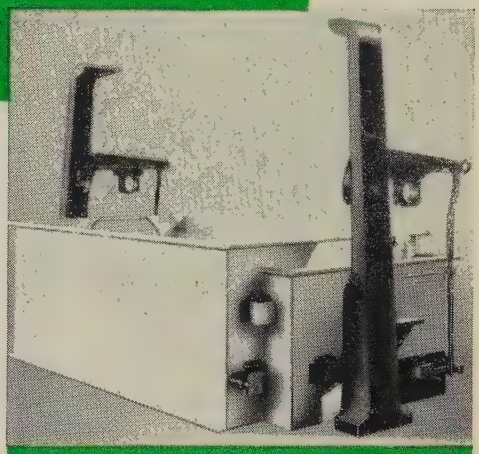
CONSERVATION *through better sheet formation with Downingtown PROFLOW and CONFLOW vats*

Conservation of timber resources is an important and vital factor in our country's economy. This conservation can go farther. It can be applied in the paper and board making industry through modernization of existing machinery.

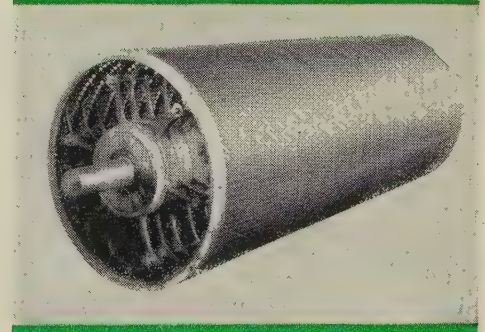
Modern efficient vats, the Downingtown Proflow and Conflow Vats, help conserve paper by insuring a better sheet formation. This results in fewer rejects and waste in the paper and board making process.

Downingtown manufactures the cylinder moulds and plain or suction type cylinder couch rolls required for board machine vats.

Find out how Downingtown Proflow and Conflow Vats can help your production. Write for specifications and performance data or consult your Downingtown Sales Engineer.



A Downingtown Stainless Steel Vat



Downingtown Cylinder Mould

MODERNIZATION IS CONSERVATION

DOWNINGTOWN MANUFACTURING COMPANY, DOWNINGTOWN, PA.

Pacific Coast Representative: John V. Roslund, Pacific Building, Portland 4, Oregon

Downingtown Fibrepulper, Manufactured in Canada by Waterous, Limited, Brantford, Ontario

DOWNINGTOWN **PROFLOW AND CONFLOW VATS**

DESIGNERS AND BUILDERS OF PAPER, BOARD AND FELT MACHINES SINCE 1880

Estimated Apparent World Paper Consumption in 1950 (*continued*)

Continent	Production, short tons	Imports, short tons	Exports, short tons	Apparent consumption, short tons	Population,[a] 1000s	Pounds/capita: Current report	Pounds/capita: 1949 report
Near East							
Arabia[b]	...	3,179	...	3,179	10,000	0.64	0.64
Cyprus	...	911[d]	...	911	484	3.76	0.67
Iran*	...	16,095	8	16,087	18,772	1.71	1.06
Iraq	...	6,046	...	6,046	5,100	2.37	1.98
Israel*	...	6,019	...	6,019	1,346	8.94	5.27
Syria and Lebanon*	...	7,223	1,821	5,402	4,484	2.41	4.08
Transjordan*	...	1,383	...	1,383	1,500	1.84	..
Turkey*	20,410	28,073	3,135	45,348	20,935	4.33	4.71
Total	20,410	68,929	4,964	84,375	62,621	2.69	2.64
Asia							
British Malaya*	...	36,603	n.a.	36,603	4,908	14.92	5.76
Burma*	100[c]	12,040	...	12,140	18,489	1.31	4.46
Ceylon	...	13,916	...	13,916	7,550	3.69	0.38
China[b]	209,437	220,460	n.a.	429,897	463,493	1.86	1.86
Hong Kong[b]	...	9,105	...	9,105	1,800	10.11	10.11
India*	121,695	105,209	1,270	225,634	358,000	1.26	1.12
Indo China*	2,500[c]	7,240	...	9,740	27,580	0.71	0.62
Indonesia*	2,204[c]	14,640	...	16,844	73,500	0.46	..
Japan*	965,811	475	21,335	944,951	83,200	22.71	11.84
Korea, South	9,280	21,190	...	30,470	20,189	3.02	0.39
Manchuria*	57,320[c]	n.a.	n.a.	57,320	42,234	2.71	..
Philippine Islands*	6,607[c]	78,622	...	85,229	19,557	8.72	7.18
Siam*	1,509	21,301	...	22,810	18,836	2.42	1.87
Total	1,376,463	540,801	22,605	1,894,659	1,139,336	3.33	2.41
Australasia							
Australia*	192,598	68,491	1,295	259,794	8,186	63.47	95.82
New Zealand*	44,615	77,853	1,321	121,147	1,948	124.38	109.48
Total	237,213	146,344	2,616	380,941	10,134	75.18	98.49

* 1950 data.
[a] Latest available population figure.
[b] Data from 1949 per capita report.
[c] Estimated.
[d] Prorated on basis of available figures.
[e] Re-exports.
[f] Includes reparations.
Sources—Trade Statistics: Department of Commerce and United Nations. Population: United Nations and *World Almanac*, 1952.

* * *

The following is a summary of the accomplishments of the Sulphite Pulp Manufacturers' Research League as recently reported:

1. Whole Liquor Research
   a. *Roadbinder.* Research grant in effect at University of Wisconsin. Eleven mills now have experimental or full-scale programs operating. At least 25,000,000 gallons of roadbinder were used in Wisconsin alone during 1951. Room remains for much expansion.
   b. *Evaporation.* Two processes in use in pilot plant. One has already proved practical; the other is still in preliminary test stages. Four mills have stainless steel evaporators on order.
   c. *Burning.* Tests have been conducted at five mills, using liquor concentrated in League pilot plant. Two mills have built or rebuilt furnaces especially designed to burn liquor, and have proved these in test runs. Four mills have new furnaces and/or boilers on order to use liquor as fuel.
   d. *Briquetting.* Research grant in effect at University of Wyoming. Much development work has been done with leading manufacturers of briquetting machinery and with the coal trade. Two successful coal processes have been developed. One of these is in full-scale commercial operation, using binder liquor concentrated in Leaque pilot plant. Experiments with iron ore now under way with mining company and other metallic ores at other experimental points.
   e. *Miscellaneous.*
      (1) *Agricultural Uses.* Tests have been made on two Wisconsin farms. No conclusive results.
      (2) *Adhesives.* Tentative explorations under way. Concentrated liquor from League pilot plant has on occasion been tested by commercial manufacturers of adhesives.
      (3) *Dispersants.* Most of the work in this field has been carried on by a member mill that makes these products for commercial use in several industries.
2. Sugar Fraction Research
   a. *Torula Yeast Process.* Originally developed in League laboratories and pilot plant. Development work on this method of using sugars now goes on at Rhinelander plant, with controls and further research in League laboratories. Technically proved, commercially promising. More than 43,000,000 gallons of spent liquor were thus processed in 1951.
      (1) *Feed Supplement.* University research projects financed by League now under way at Wisconsin, Minnesota, and Michigan State. Animal and poultry feed manufacturers are the basic big-volume market for torula yeast.
      (2) *Human Nutrition.* Rhinelander plant now meeting highest technical standards for human food and pharmaceutical uses. This field is being explored. Small but desirable market potential.

the difference is in the coating!

ACCO® Domestic and DAIRYCO® Argentine Caseins assure the smooth, level coat that "moves" printing papers!

Cyanamid-Supervised In All Stages of Production...

ACCO Brand Domestic Casein is noted for its absolute uniformity and unsurpassed quality.

Meeting Every Requirement For An Imported Casein...

DAIRYCO Brand Argentine Casein is a recognized high-quality coating and binding agent.

For Lower Viscosity In Starch-Clay Coating Operations...

AZITE® 900 Liquefier exerts an efficient thinning action on the finished coating color. An excellent performer in machine-coating formulas.

For Effective Control of Pitch Troubles...

ACCOCEL* 741 Pitch Dispersant prevents formation of pitch agglomerates which plug screens, stick paper to press rolls and driers, and make spots in the sheets.

For Pigment Dispersion...

ACCOCEL 741 has proved particularly effective in the dispersion of pigments and fillers. Better retention in the paper and better color in the sheet are realized even when running a color such as carbon black.

For Skilled Technical Assistance...

Call on Cyanamid's Technical Service Staff. Its men are all industry-trained in every phase of paper-making. They will be glad to assist you with any problems involving the use of paper chemicals.

Cyanamid Paper Chemicals: ALWAX* Sizes • WAXINE® Sizes • ACCOCEL* ACCOBRITE® Rosin Size • Rosin Size • PAREZ® Resins • Synthetic Resins Casein • Sulfonated Oils • Fillers • Defoamers • Soda Ash • Caustic Soda Salt Cake • Acids • Clays • AEROSOL® Wetting Agents • CALMICRO® Calcium Carbonate • AZITE® 900 Liquefier • Aluminum Sulfate • Sodium Phospho Aluminate.

*Trade-mark

Sales Offices: Boston • Philadelphia • Pittsburgh • Baltimore • Charlotte • Cleveland Cincinnati • Chicago • Detroit • Kalamazoo • St. Louis • Los Angeles • San Francisco • Seattle

AMERICAN Cyanamid COMPANY

INDUSTRIAL CHEMICALS DIVISION DEPT. T-4.

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

(3) *Raw Material for Chemical Processing.* Specialist consultants have been used in this new field. The material is under experiment by chemical and pharmaceutical manufacturers both as a nutrient in biochemical processes and as a source of organic chemical raw material.

b. *Other Fermentation Processes.* Theoretically it is possible to use other types of organisms causing fermentation than *Torulopsis utilis* to consume the sugars in spent sulphite liquor. Different fermentations yield different end products. Fuel gases, plastic intermediates, and synthetic rubber ingredients are long-range possibilities. Preliminary work is being done along the more promising lines, and consultations have been held with scientists whose interests lie in related directions.

c. *Basic Research on Sugars.* Industry's greatest technical advances usually follow basic studies that have no immediate commercial goal. We need to know more about the nature and behavior of wood sugars before we can deal with them most effectively. In 1951, such a long-range project was started and a sugar chemist was added to the staff.

3. Lignin Fraction Research

a. *Chemical Derivatives.* From lignin the organic chemist can derive many other products. The Institute of Paper Chemistry handles our lignin research and much progress has been achieved. Vanillic acid derivatives have been particularly interesting to several medical research groups. Clinical tests show promising results in treating a number of stubborn and serious diseases, some of them usually fatal. One of this country's best known pharmaceutical manufacturers is preparing to produce and market drugs thus developed.

b. *Insolubilization.* Lignin has excellent adhesive qualities, but because it is soluble in water has a narrower potential market than if it were water-resistant. To render lignin insoluble in water without decreasing its adhesive qualities is one of the objectives of this study.

4. Recovery of Pulping Chemicals

a. *Sulphur Dioxide.* This dissolved material contributes somewhat to the Biochemical Oxygen Demand (B.O.D.) of spent sulphite liquor. As long as the present sulphur shortage continues, recovery of SO_2 for re-use in pulping can support a relatively high processing cost. Layout of a particular mill largely determines whether this is practical. Two member mills have installed SO_2 recovery system, and several others are studying the possibilities with the aid of League data.

b. *Recovery of Pulping Chemicals.* Theoretical opportunities exist for recovering ammonia and sodium in sulphite pulping processes other than the conventional calcium base process. Several member mills have experimented with noncalcium processes, but because of low cost of the base chemicals little active research has been justified.

* * *

Modern lithographic presses are miracles of mechanical design and precision machining. Only slightly smaller than a box car . . . and much heavier . . . a 50 by 72-inch four-color rolls out 6000 sheets an hour, with register accurate to the thousandth of an inch and with surprisingly little vibration. Some single-color presses take sheets as large as 72 by 84, and there are web-fed presses that do 32,000 impressions an hour. Because of the offset principle, lithography permits fine screen reproduction on uncoated or textured papers . . . an important factor in the ever-increasing popularity of this process.

Popular Sizes and Sizes of Offset Presses

	Maximum sheet	*Minimum sheet*	*Printing area*	*Rated speed*
Hoe Web Offset Jobber	8 1/2 × 14	8 1/2 × 10	8 3/16 × 13 3/4	30,000
Imperial Litho King	8 1/2 × 14	8 1/2 × 8	8 1/8 × 13 3/4	32,000
ATF Webendorfer Little Chief "20"	14 × 20	8 × 10	13 × 19 1/2	5,000
Harris 17 × 22 LTG single color	17 1/2 × 22 1/2	10 × 14	17 1/8 × 22 1/2	7,000
Webendorfer 17 × 22 MA[a]	17 × 22	8 × 10	16 1/2 × 21	5,000
Dutro Photochrome Dry Offset 2-4-6 color	17 1/2 × 22	10 × 22	17 1/2 × 21 1/2	15,000
ATF Webendorfer 17 × 22 Chief "22"	17 1/2 × 22 1/2	8 × 10	17 × 22	5,000
Rutherford 20 × 26	19 × 25	8 1/2 × 11	19 1/2 × 25	6,000
McAdams Press	19 1/2 × 25 1/2	8 × 10	19 × 25	6,000
Jeep Offset Press	19 1/2 × 25 1/2	8 1/2 × 11	19 × 25	6,000
Babcock Talisman	19 1/2 × 25 1/2	8 × 10	19 × 25	7,000
Rutherford 20 × 28	20 × 28	11 × 14	19 1/2 × 28	6,000
Harris 21 × 28 LTC single color	22 × 30	10 × 14	21 5/8 × 29	6,500
Webendorfer 22 × 26[a]	22 × 26	11 × 17	20 × 26	5,000
Harris 22 × 34 LTN 1-2 color	23 × 36	11 × 17	22 1/2 × 35	6,000
ATF Webendorfer Big Chief "29"	22 1/2 × 29	11 × 17	22 × 28	5,000
E. B. Co. single color	22 × 34	11 × 17	22 1/2 × 35	6,000
Miehle No. 44 Unit Type 1-4 color[a]	29 × 43	16 × 24	28 1/2 × 42	5,000
Hoe 30 × 42 single color[a]	32 × 43	17 × 22	29 3/4 × 42 3/4	5,000
Potter B 3[a]	34 × 46	16 × 19	33 11/16 × 46	3,500
Dutro Web Offset 45 1/2 × 38 1-6 color	37 1/2 × 45 1/2	22 × 45 1/	44 7/8 × 37	9,000
Harris 35 × 45 LSS 1-2 color	35 × 45	17 × 22	35 5/8 × 47 1/2	5,000
Potter B-D 4[a]	38 × 52	16 × 19	37 11/16 × 52	3,500
Dutro 38 × 52 2-6 color			37 3/8 × 51	
Potter B-D4 Special[a]	41 × 54	16 × 19	40 11/16 × 54	3,500
Miehle No. 57 Unit Type 1-4 color[a]	41 1/2 × 55 1/2	19 × 25	41 × 55	4,500
Hoe 41 × 54 1-2 color[a]	42 × 55 1/2	19 × 25	41 1/2 × 55	4,500
Miehle No. 61 1-4 color	42 × 58	22 × 34	41 5/8 × 58 1/2	6,500
Harris 42 × 58 LTK 1-2-4 color	43 × 59	22 × 34	42 5/8 × 58 1/2	6,500
Miehle No. 69 Unit Type 1-4 color[a]	46 1/2 × 67 1/2	24 × 34	46 × 67	4,500
Harris 50 × 72 LTQ 1-2-4 color	50 × 72	25 × 38	49 5/8 × 71 1/2	6,000
Hoe 50 × 72 1-6 color	50 × 72	25 × 36	49 1/2 × 71 1/2	6,000
Miehle No. 76 1-4 color	52 × 76	28 × 42	51 5/8 × 76	6,000
Harris 52 × 76 176 single color	52 1/2 × 77	25 × 38	52 1/2 × 76 1/2	6,000
Harris 52 × 76 276 2 color	52 1/2 × 77	25 × 38	52 1/2 × 76 1/2	6,000
Harris 52 × 76 476 4 color	52 1/2 × 77	25 × 38	52 1/2 × 76 1/2	6,000
ATF Webendorfer, 4 color web	30 × 40			10,000

[a] Not presently manufactured, but in general use.

They Set the Standard for Quality

These seals are stamped on all Brown Company Solka and Cellate pulps. They are your assurance of the finest quality pulps manufactured from wood cellulose—pulps that set the standard for quality in the industry. Here's why:

Brown Company pulps are made principally from its own vast timberlands of northern softwood and hardwood. This assures quality control and a dependable source of raw material.

Brown Company research laboratories are constantly producing new fibres that enable the paper industry to take advantage of the versatile characteristics of wood cellulose. They were the first to make it economical and practical to use hardwood fibres in the manufacture of many products.

Our Technical Service Division is ready to work with you on any paper problem, however difficult it may be. Write Dept. DP-4. in our Boston office.

BROWN QUALITY COMPANY, Berlin, New Hampshire
CORPORATION, La Tuque, Quebec

General Sales Offices: 150 Causeway St., Boston 14, Mass.—Dominion Square Bldg., Montreal, Quebec

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ONCO INSOLES • CHEMICALS • BERMICO SEWER PIPE, CONDUIT & CORES

The University of Maine Pulp and Paper Foundation presented George D. Bearce, of Bucksport, Me., its 1952 Honor Award "in recognition of outstanding service to the pulp and paper industry in management and technology." Mr. Bearce is general manager of St. Regis Paper Co. operation in the State of Maine. The award was presented by J. L. Ober, Vice-President of the Scott Paper Co., Chester, Pa., who is chairman of the Foundation's executive committee.

Head Table at University of Maine Pulp & Paper Luncheon, l. to r.: Clifford Patch, Dean Ashley Campbell, Robert Ramsdell, J. L. Ober, Lyle C. Jenness, George D. Bearce

The presentation was made at the annual meeting of the University of Maine Pulp and Paper Alumni at a luncheon at the Biltmore Hotel, New York, N. Y. Robert Ramsdell, of the Paper Makers Chemicals Div., Hercules Powder Co., Holyoke, Mass., was chairman of the luncheon meeting. Professor Lyle Jenness, head of the chemical engineering department at the University, also spoke.

Honor Award Presentation at University of Maine Pulp & Paper Luncheon, l. to r.: J. L. Ober presenting award to George D. Bearce

Established about two years ago, the Foundation is designed to interest students in the university's pulp and paper program, to provide loans and scholarships for these students, to interest students and men from industry in advanced study, to screen outstanding students for the five-year operational management program, to augment the teaching staff, and to advance fundamental and applied research.

Mr. Bearce is a member of the Technical Association of the Pulp and Paper Industry and a member of the American Society of Mechanical Engineers. He has been greatly interested in Boy Scout work and has received many special honors for his volunteer work in this field. He has also taken an active part in many other civic affairs.

The recipient of the Foundation's first Honor Award last year was Dr. Ralph H. McKee of New York. Dr. McKee was honored for having started the first college course in pulp and paper technology in the country at the University of Maine in 1913.

* * *

Are employers in the pulp, paper, and paperboard industry generally complying with the amended Fair Labor Standards Act? Does the record indicate that management has a firm grasp of the Fair Labor Standards Amendments that went into effect on Jan. 25, 1950? Recently released statistics on the first full year of operations under the amended Federal Wage and Hour Law show that there is room for improvement.

According to the 1951 annual report of the U. S. Labor Dept.'s Wage and Hour and Public Contracts Divisions, 62% of the establishments investigated in this industry during the past fiscal year were found to have violated the Act's minimum wage, overtime pay, or child-labor provisions.

"The 1951 record makes it clear that greater efforts on the part of some pulp, paper, and paperboard manufacturers would pay off in reduced liabilities for back wages owed employees," points out Wm. R. McComb, the Divisions' Administrator. His report shows that a total of $17,644 in back wages was paid to 204 employees. This sum does not include amounts awarded by courts to employees who exercised their statutory right to sue for back pay and liquidated damages.

"Although most employers know that the amendments raised the minimum wage to 75 cents an hour from 40 cents, the Divisions found that a sizable minority of establishments —11% of those investigated—had failed to observe this requirement when paying some of their employees," states McComb.

"Even more extensive were overtime pay violations, found in 60% of the investigated establishments. Employers should remember that the amended Act continues to require payment of at least time and one-half the employee's regular rate of pay for all hours worked in excess of 40 in the work-week, except where the Act specifically provides otherwise. What the amendments did was to define the regular rate to include all remuneration for employment except certain specified payments."

Failure to comply with the Act's child-labor provisions was disclosed in 4% of the investigated establishments. The child-labor requirements set a minimum age of 16 for most jobs with 18 as the minimum for occupations designated hazardous by the Secretary of Labor. Employment of boys and girls of 14 and 15 years of age is permitted in a few types of jobs—such as office and sales work—under strict restrictions on hours and working conditions.

The Administrator wants members of the industry to know that the violations found last year were not representative of the compliance record of all employers whose employees come within the provisions of the Act. The Divisions' policy is to make investigations where there is reason to believe that violations will probably be found. Moreover, experience demonstrates that the great majority of employers intend to comply with the Act; in most cases, failures are due to misunderstandings about the statutory provisions.

To assist the pulp, paper, and paperboard manufacturers in attaining full compliance, McComb invites any employer who has questions about the Federal Wage and Hour Law to inquire of the nearest regional office of the Divisions. These offices are located in the following cities: Boston, New York, Philadelphia, Birmingham, Cleveland, Chicago, Kansas City, Dallas, San Francisco, and Nashville.

* * *

Oy Keskuslaboratorio—Centrallaboratorium Ab, the Finnish pulp and paper industries research institute for technical and scientific work has been functioning for 35 years. It has expanded to keep pace with the development of our forest

AN-BAC...

ORR'S ANTIBACTERIAL PAPER MILL FELTS

What makes felts seem to wear out when they are lying idle on the paper machine?

Why do felts unaccountably tear off the machine after a week-end shutdown?

Why do felts develop holes in 20 to 30 days on the machine in spite of actually running only five to ten days?

THE ANSWER IS BACTERIA.

Though you can't see them, you can see what they do.

As everyone knows, bacteria are always in the air to attack dead animal and vegetable matter. Nature has made this provision in order to restore the fertility of the soil.

The presence of moisture in paper mill felts in the mill makes the wool fibres an inviting feast for bacteria! They simply follow their inherent urge to grow and multiply in such an environment.

Knowing that bacteria are always on the alert to infest paper mill felts, the logical thing to do is to apply preventive measures. And that's exactly what we do when we give Orr felts the AN-BAC antibacterial treatment.

MORE FACTS ABOUT BACTERIA AND AN-BAC

Bacteria rob paper manufacturers of many days of potential felt life every year.

Bacteria-injury can be seen in nearly every used felt.

Bacteria cause the loss of many tons of production on account of excessive shutdowns for felt repair and replacement.

AN-BAC FELTS are treated by a special process which makes the wool resistant to bacterial attack.

AN-BAC FELTS solve the problem of paper mill felt decay.

AN-BAC FELTS start fast . . . last long.

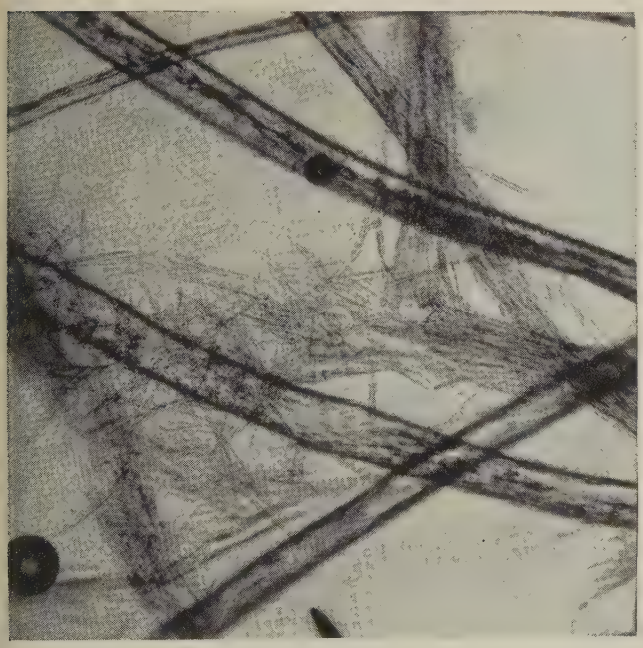
Testing of over 800 ORR Felts has proved the value of AN-BAC treatment.

Order your AN-BAC felt today.

Discuss your felt problems with your ORR representative.

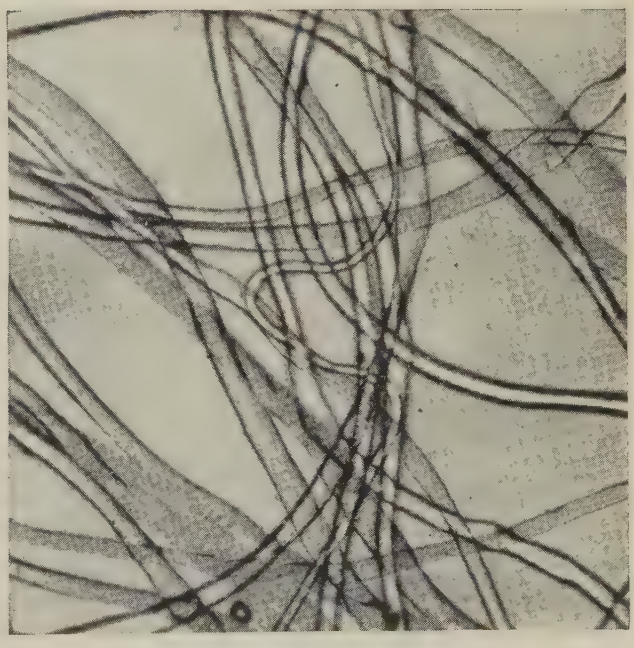
GET THE LONGEST RUN FOR YOUR MONEY WITH ORR'S AN-BAC FELTS.

EFFECTS CAN BE SEEN, THOUGH NOT THE CAUSE



THE WORK OF BACTERIA

Here's a microphotograph of moist wool after only FOUR days of uninhibited bacterial attack. The disintegration of the fibres is clearly visible. This is what generally happens to untreated paper mill felt, especially during periods of idleness.



STERILIZATION AVERTS DAMAGE

Above is a magnified view of moist wool, AN-BAC-treated, after 28 days of exposure to bacteria. You can see that the fibres are undamaged.

In comparing the two microphotographs, keep in mind the four days vs. 28 days. Bacteria work fast. Their number doubles, trebles, or quadruples every hour under favorable circumstances.

THE ORR FELT & BLANKET CO., PIQUA, OHIO

industry and has won recognition for its work in other countries as well as in Finland.

The idea of founding the Central Laboratory was formulated during the First World War. It was to function as a private enterprise serving the industry as a central laboratory which would undertake various investigations and tasks. Keeping pace with the expansion and development of the industry the Central Laboratory has itself expanded and its work has become more varied. In 1924 the laboratory was housed in a building of its own in Helsinki, in 1933 an extension was finished, mainly for technical experimental work on pulp cooking and beating, in 1942 the laboratory was entirely modernized and in 1946 and 1949 the laboratory was again expanded by renting and fitting up additional space in adjacent houses. In 1943 the paper, pulp, groundwood and board industries bought the stock majority in the institute.

The work of the Central Laboratory is divided into two main groups. About two thirds of the work is research work. This research is directed at the improvement of production methods, the discovery of new products, the improvement of potential uses for raw materials, the development of analytical methods etc. Each of the industries owning the laboratory has appointed a technical committee to draw up research programs and to supervise the research work. Thus the pulp, paper, groundwood, and board industries each have their own technical committees with the necessary subcommittees. About one third of the work consists of private research problems submitted by different mills etc., and this includes such questions as the causes of operation troubles and reclamations, the quality control of products, and similar program research to that done under the supervision of the technical committees. In addition, much direct laboratory service is given to the industry in general and to the general public. These services include work mainly on the raw material questions of the industry, fuel and water etc.

At present there are 13 departments in the laboratory: different pulp departments for experimental cooking, bleaching, and analysis, and rayon, paper, groundwood, and board departments. In addition to these there are general departments for inorganic and organic chemistry and biochemistry and documentation service. The Central Laboratory employs about 140 persons of whom about 45 are college graduates. The utilizable laboratory area is 2600 m.^{2}. The chairman of the board of directors is R. Erik Serlachius and the chairman of the executive committee, Lauri Kanto. Bertil Nybergh, Ph.D. acts as managing director.

There is also a close cooperation between the laboratory and the universities. Several students carry out their graduate works there and reciprocally, the institute has found it necessary to employ scientists in the universities to carry out researches of a fundamental nature as private commissions.

Special attention has been paid to the development of the library and documentation service. This functions as an independent department in the institute and is an important auxiliary for research work and for the industry in general.

* * *

Graton & Knight Co., Worcester, Mass., has issued a 40 page catalog and manual on leather belting. The bulletin contains interesting data sheets showing horsepower ratings, belt speeds in feet per minute, and determination of the length of belts.

* * *

At its laboratory in Passaic, N. J., Raybestos-Manhattan, Inc., now has the world's largest laboratory conveyor belt testing machine. It was designed by the Company's engineers. It will take belts up to 30 inches wide. Up to 200,000 pounds total tension can be applied.

* * *

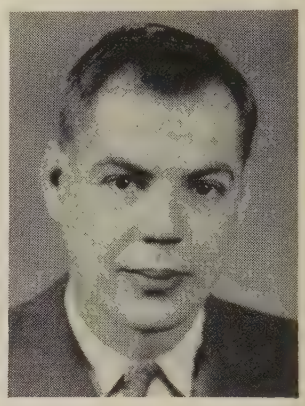
William R. McNally has been appointed representative of the Link-Belt Co., Chicago, Ill., for the pulp and paper industry, succeeding H. F. R. Weber who has resigned and now lives in Florida.

Raymond S. Wood has been appointed general manager of Link-Belt Co.'s ball and roller bearing plant (Dodge plant) in Indianapolis, Ind., to succeed C. V. Loughery who has retired after 50 years of service.

* * *

The Allied Paper Mills, Kalamazoo, Mich., has announced the following promotions: Charles W. Lillie to Superintendent of Manufacturing and Development of the Photographic Div.; John R. Dam to Chief Chemist; and H. Ray Hall to Assistant Technical Director.

C. W. Lillie, Allied Paper Mills



J. R. Dam, Allied Paper Mills

Antone Horstman was recently appointed manager of laboratory operations for Bauer Bros. Co., Springfield, Ohio. He is in charge of both the pulp and paper and the feed and milling laboratories. He was formerly process engineer for Weston Paper Co. at Terre Haute, Ind.

Antone Horstman, Bauer Bros. Co.

H. R. Hall, Allied Paper Mills

* * *

Titanium Pigment Corp. has advised that titanium pigments, in short supply since 1943, are now available in unrestricted quantity. Plant expansion since the end of World War II has made this possible.

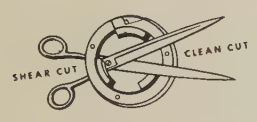
* * *

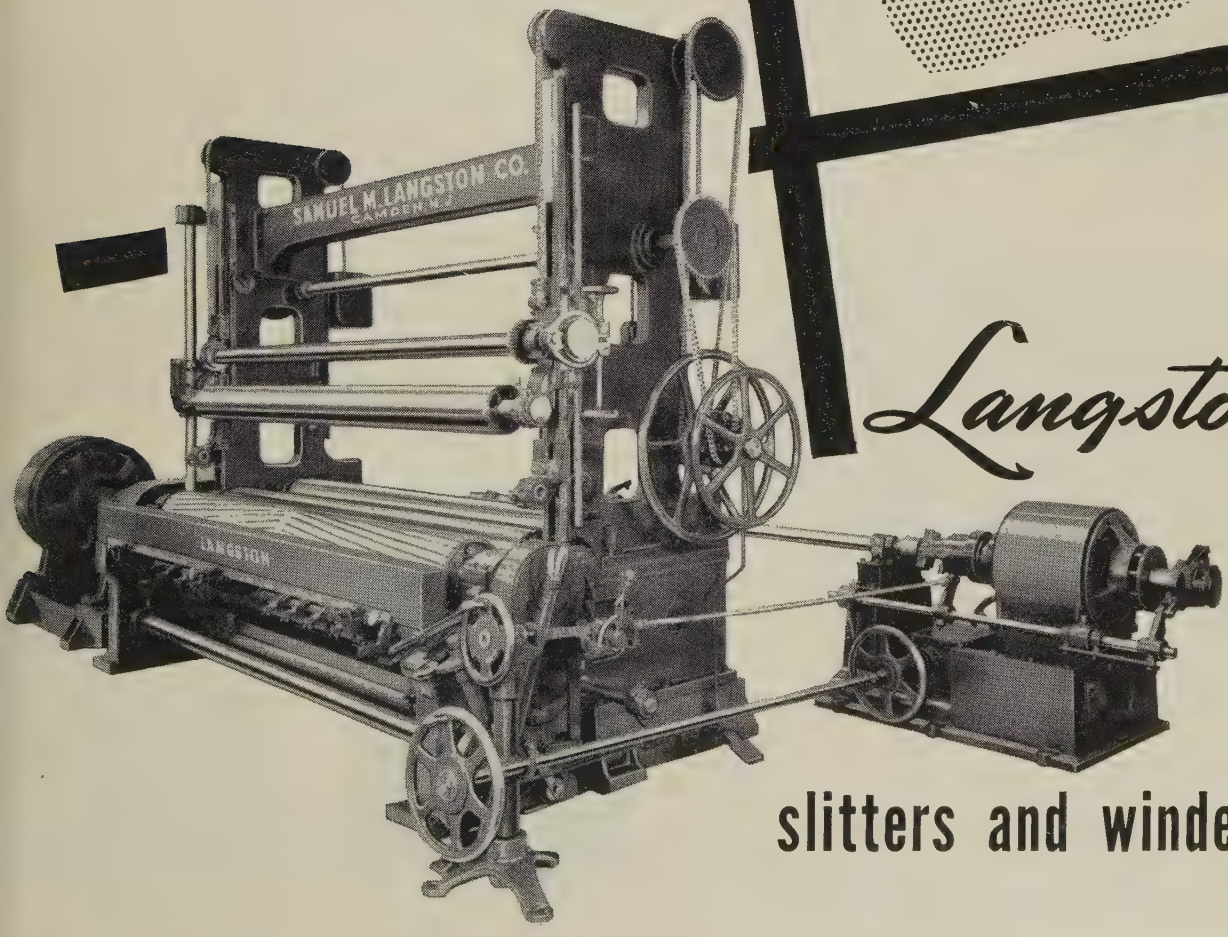
Joseph E. Moran, General Sales Manager of the Dicalite Div., Great Lakes Carbon Corp., has been elected President of the Dicalite Co., a special sales agency for distribution of

Performance

All Langston Slitters and Winders are noted for exceptional performance with low maintenance costs. Here's Type "CA"—ideal for many Winder or Rewinder jobs, from 62″ to 122″. It can be built to operate at speeds up to 3000 f.p.m. and to handle rolls up to 60″ in diameter or, on special order, 72″.

SAMUEL M. LANGSTON COMPANY
CAMDEN, N. J.





Langston

slitters and winders

Dicalite products in selected areas. His headquarters will be in Los Angeles, Calif.

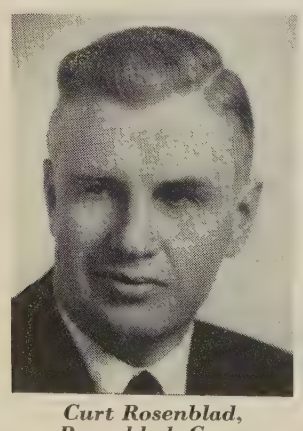
* * *

American Cyanamid Co.'s suggestion plan completed its first year with a record number of suggestions of 126 per 100 employees, several times the national average for industry. Total awards to employees for the 5342 suggestions that were adopted in 1951 totaled $68,500. Of these, 40 were $100 or higher. Altogether 26,986 suggestions were submitted. The two highest awards were $3380 and $3410. The first amount was awarded for a suggestion that a steam valve be turned off during part of a manufacturing process. Particular effort is made to encourage ideas leading to a reduction of waste materials, supplies, machinery, equipment, electricity, fuel, and water.

* * *

Over the past 20 years, Rosenblad designs and processes have attained pre-eminence in the European wood pulp industry. The necessity for rigid fuel economy in Europe, particularly in Scandinavia, stimulated the demand for efficient waste heat recovery methods. To meet these needs, Rosenblads Patenter, Stockholm, Sweden, developed the spiral plate heat exchanger, the Rosenblad blow steam heat recovery system, and the Rosenblad heat and SO_2 recovery system.

The success of these developments in Europe brought about the organization of American Heat Reclaiming Corp. in 1936 for manufacture and sales in the United States and Canada. Although the spiral exchanger had been designed for pulp process application, an extensive market was found in the general industrial, chemicals, and food processing fields.



Curt Rosenblad, Rosenblad, Corp.

Subsequent Rosenblad developments in the line of jet condensers, eductors, spent liquor evaporators,* switching method for descaling evaporators, and indirect cooking for sulphite pulp, indicated the need for a sales and technical unit in the United States, for which the Rosenblad Corp. was organized in 1946. In addition to Rosenblad developments, the Rosenblad Corp. is the sales and technical representative for Markila-Brax diffuser washing method and Sandberg central dumping valves for diffusers.

To be in a position to offer a fully integrated line of equipment and processes and technical service, Rosenblad Corp. has acquired from American Heat Reclaiming Corp. the exclusive sales rights in the United States and Canadian pulp industries for the spiral heat exchanger and the Rosenblad blow steam and heat and SO_2 recovery systems.

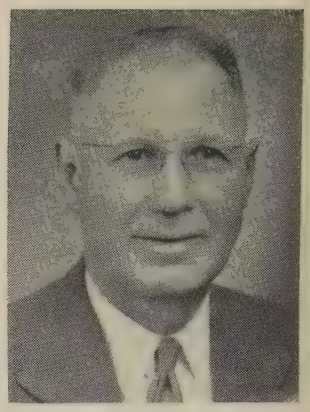
Curt Rosenblad, President of Rosenblad Corp., and founder of Rosenblads Patenter, established permanent residence in the United States in 1949. Mr. Rosenblad makes periodic visits to Sweden, and has expressed the belief that an increased exchange of experience and ideas between the two big wood pulp-producing areas—the United States and Canada on one side, and Scandinavia and Finland on the other side—will be of mutual benefit to both sides.

*Manufacturing and sales rights in the United States for Rosenblad switching method evaporators have been assigned to General American Transportation Corp.

* * *

James B. Hoxie has been appointed Western Division Sales Manager of Oliver-United Filters, Inc., Oakland, Calif.

J. B. Hoxie, Oliver-United Filters



C. R. Crawford, The Black-Clawson Co.

Mr. Hoxie succeeds Philip J. McGuire who has been appointed Director of Research and Development.

* * *

C. R. Crawford, Black-Clawson President, has been touring with Black-Clawson representatives in Italy, France, Switzerland, Germany, Holland, and Belgium. Mr. Crawford also visited with the principals of the Black-Clawson British subsidiary company; B-C International, Ltd., in London.

Frank T. Peterson, new Assistant General Manager of The Black-Clawson, Hamilton, Ohio, Division, recently arrived in London for an indefinite tour of duty with the B-C London subsidiary, B-C International, Ltd., where he serves in the capacity of Deputy Managing Director.

The rapidly increasing volume of business of the B-C International subsidiary makes it necessary to increase considerably the size of the British subsidiary staff over the period of the next few months.

Michael B. Gormely, Black-Clawson Service Engineer, is now in Italy to assist the Cartiera Italiana firm in the start-up of their new Black-Clawson cigarette tissue machine which was recently erected under the supervision of B-C Engineer, Charles Miller. This new fourdrinier machine installed at the Italiana mill in the foothills of the Italian Alps, will supplement the production of ten other such machines in that mill operating on cigarette and other fine tissue grades.

The Black-Clawson Co. has announced the appointment of Frits Madsen as Sales Manager of B-C International, Ltd., British subsidiary of Black-Clawson in London, England. Mr. Madsen, formerly General Superintendent of the Ny Maglemalle Mill of DeForenede Papirfabrikker in Denmark, enjoys wide experience in the European paper industry, covering both the theoretical and the practical aspects of papermaking.

F. T. Peterson, The Black-Clawson Co.

M. B. Gormely, The Black-Clawson Co.

Plagued by pitch?

...Control it with CELITE

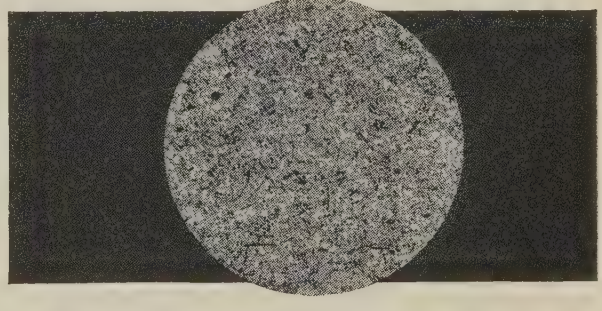
If green wood is aggravating the problem of pitch control in your mill, here's a suggestion that may be of help:

Try adding about 1% of Celite* at the beaters. Many mill operators find this a practical and economical cure for pitch trouble.

Celite works like this: Its porous, absorbent, and minute particles coat the individual pitch particles and destroy their stickiness. The Celite-coated pitch particles pass through the system, becoming an integral part of the sheet. Machines stay clean . . . paper quality high . . . and the cost of the Celite used is largely recovered when the paper is sold.

Why not let a Celite engineer make on-the-spot recommendations for controlling pitch in your mill? He will also acquaint you with other important Celite advantages that may help you turn out better paper at lower cost. Just write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, address Canadian Johns-Manville Co., Ltd., 199 Bay Street, Toronto, Ontario.

Yours for the asking—Bulletin FA-31A gives helpful information on how to control pitch with Celite. You can get your copy by writing to the address above.



This photomicrograph shows the minute, porous Celite particles which, by coating pitch, destroy its stickiness, and prevent build-up of agglomerates.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CELITE PRODUCTS

FOR THE PAPER INDUSTRY

Having supervised the installation, start-up, and operation of all B-C-S-D equipment recently added to DeForenede's Ny Maglemalle stock preparation systems, Mr. Madsen is thoroughly familiar with the complete line of Shartle-Dilts stock preparation equipment built and sold by B-C International, Ltd., and by the American divisions of the Black-Clawson Co. A graduate chemical engineer, Mr. Madsen also holds a Master's Degree in straw utilization and has just recently received his Doctor of Philosophy Degree in Papermaking Techniques. Mr. Madsen's thesis for his doctorate degree was "The Control in Consistency Variation Throughout the Stock Preparation System."

* * *

A new research laboratory is being built by National Starch Products, Inc., to provide additional facilities for research on adhesives and resins, particularly vinyl acetate copolymers, which National has been making for some time for use in its own adhesive formulations and has recently begun supplying to other users on a "custom-made" basis. An 8-acre tract adjoining its Plainfield-Dunellen plant has just been purchased for this purpose and by the time this goes to press construction should be started.

Architect's drawing of the National Starch Products Inc. research laboratory to be erected in Plainfield, N. J.

A 4-page folder on vinyl acetate polymers and copolymers in solution and emulsion form is now available from National Adhesives Div. of National Starch Products, Inc., 270 Madison Ave., New York City 16, N. Y. To illustrate some of the variations in properties which National has been able to obtain with polyvinyl acetate and its copolymers, the folder lists properties of five typical solutions and five typical emulsions. A table of solution properties includes solids content, viscosity, film hardness, and intrinsic viscosity. A table of emulsion properties gives solids content, pH, particle size, solvent tolerance, and freeze-thaw stability. The booklet also discusses compatibility of the solutions and emulsions with modifiers, the use of plasticizers, and potential applications of the resins.

* * *

In connection with recently increased production facilities of methocel (methylcellulose), the Dow Chemical Co., Midland, Mich., has reached an agreement with seven distributing firms throughout the country to handle sales. These new agents are: Braun-Knecht-Heinman, San Francisco; Braun Corp., Los Angles; Van Waters & Rogers, Portland, Seattle and Spokane; Innis, Speiden & Co., Chicago and New York; Merchants Chemical Co., Chicago, Cincinnati, and Milwaukee; G. S. Robins & Co., St. Louis; J. J. Leidy & Co., Baltimore; and George Mann & Co., Providence. Methocel is a synthetic gum serving as an adhesive, film former, thickener, binding and stabilizing agent.

Dow has announced that it is now possible for paper mills with size press facilities to apply latex base clay coatings to paper. For mills who may not have conventional coaters, size-press formulations using Dow latex 512-K permit the manufacture of a new line of paper without modification of existing equipment or investment in special coating equipment. Because of the thermoplastic nature of 512-K, supercalendering gives the sheet improved smoothness. Papers coated at the size press with this latex adhesive open market possibilities for book papers, offset papers, label and packaging-base papers requiring good lacquer and varnish hold-out.

* * *

Norman R. Meier has been appointed sales application engineer to the Boston district sales office of the Reliance Electric & Engineering Co.

* * *

Canadian pat. 480,929 (Feb. 5, 1952) relative to chip and chemical storage bins has been granted to A. T. Hurter and assigned to the Stadler, Hurter Co. of Montreal.

* * *

Joseph P. Nugent has been elected Vice-President and Manager in Charge of Engineering-Sales of the United States Wallboard Machinery Co., New York, N. Y.

* * *

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa., has issued a new 20-page booklet (B-4731) on the Design and Application Features of Life-Line Motors (now made in ratings up to 700 hp.). This type motor is used in the paper industry.

Chris H. Bartlett has been appointed Manager of the Transformer Div. of Westinghouse.

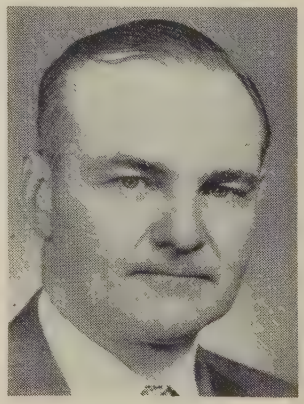
* * *

Paisley Products, Inc., 1770 Canalport Avenue, Chicago 16, Ill., has issued a new 8-page illustrated Technical Service Bulletin on "Round Container Labeling." Sections in the bulletin deal with food container labeling, description of labeling methods, spot labeling, and wraparound labeling. Photographs show the labeling machines made by: Food Machinery and Chemical Corp., Sprague-Sells Div., Hoopeston, Ill.; Burt Machine Co., Baltimore, Md.; Standard-Knapp Div., Hartford-Empire Corp., Portland, Conn.; Chishold-Ryder Co., Hanover, Pa.; Potdevin Machine Co., Brooklyn, N. Y.; Kenneth J. Moore & Co., Chicago, Ill.; and Schaefer Machine Co., Bridgeport, Conn.

* * *

Francis W. Hoye, formerly Director of the Mechanical Engineering Depts. of Rhode Island State College and Syracuse University, has been appointed Director of Engineering for Jackson & Church Co., Saginaw, Mich.

Harold E. Graves, formerly in Charge of the Chemical Engineering Dept. at Rhode Island State College, will direct chemical engineering at Jackson & Church.



F. W. Hoye, Jackson & Church Co.

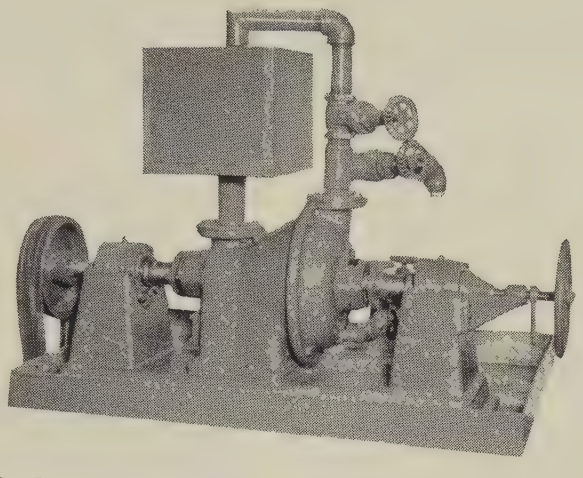
H. E. Graves, Jackson & Church Co.

HERMANN *Improved* CLAFLIN

"Continuous Beater & Refiner

Arrangement for single or multiple passes or recirculating for making strength development curves on pulps in a very few minutes as well as checking to see if maximum strength is being developed with present beating and refining equipment.

Unit minus piping, headbox, valves and motor furnished on a loan or trial basis.



Comparable fillings available as furnished in No. 1, 2 and 3 size Claflin.

Operation speeds from 400 to 900 RPM and with 5 to 20 H.P.

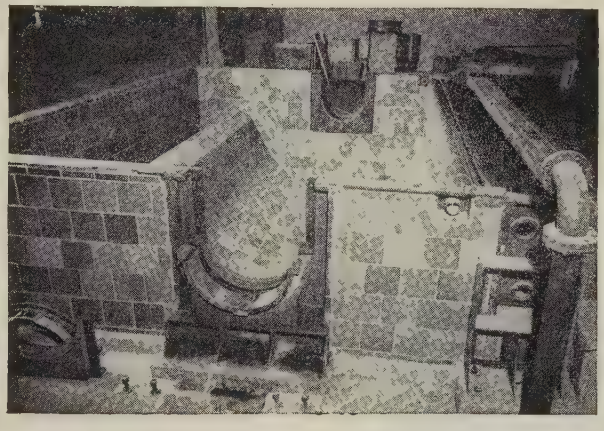
Auxiliary Plug and Quick-Change Plug Liner.

Cycling pulp for molded products at rate of 500# per hour, 15 H.P. and 860 RPM.

NO. 0 CLAFLIN FOR LABORATORY TEST PURPOSES

EXCLUSIVE SALES AGENT: **THE EMERSON MFG. CO.** LAWRENCE, MASS.

THE HERMANN MFG. CO., LANCASTER, OHIO



STEBBINS SEMTILE and SEMPLATE CONSTRUCTION

—is extensively used to provide better operation and longer life for vessels, chests, treating or storage tanks used in the pulp and paper industry.

Whenever you have a lining or tank problem consult a Stebbins engineer. This advice is based on experience gained over many years devoted to meeting the needs of pulp and paper mills.

A consultation involves no obligation on your part and may save thousands of dollars in future operating and maintenance costs.

SEMCO

Stebbins Engineering and Manufacturing Company

WATERTOWN, NEW YORK

CANADIAN STEBBINS ENG. & MFG. CO., LTD. – CASTLE BLDG., MONTREAL, CANADA

STEBBINS ENGINEERING CORP. – TEXTILE TOWER, SEATTLE, WASH.

Mason-Neilan Regulator Co., 1190 Adams Street, Boston 24, Mass., has issued a new catalog on Automatic Controls (No. 52), together with several instruction sheets on control equipment.

* * *

Rohm & Haas Co. has opened a new office and warehouse in Charlotte, N. C., to serve paper mills and other industries in the southeast. An outstanding feature of this new facility is the installation of two 10,000-gallon capacity storage tanks to permit loading of tank-truck quantities of liquid resins, particularly Uformite-435 and other adhesives in the Uformite series.

* * *

William J. Vogel and Robert M. Hatfield have been elected Vice-Presidents of Combustion Engineering-Superheater, Inc. Mr. Vogel is also chief engineer. Mr. Hatfield is General Manager of the Western Division with headquarters in Los Angeles.

* * *

Miles W. Burleson has been appointed Assistant Manager of the Insulation Dept. of Johns-Manville Corp., New York, N. Y.

* * *

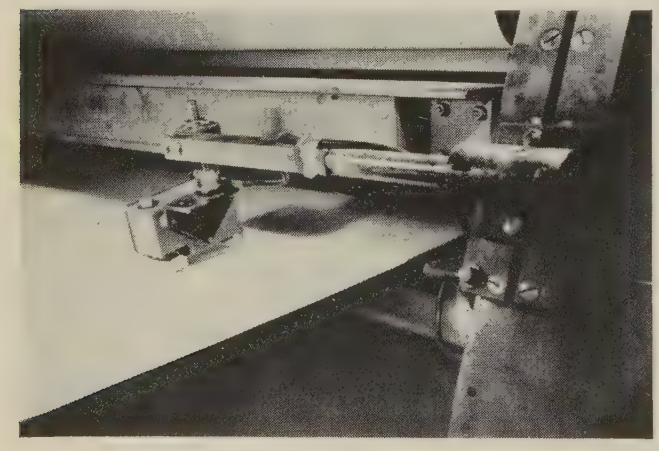
Witco Chemical Co., 295 Madison Avenue, New York, N. Y., has issued a 12-page Technical Service Report (P-17) on Mildewproofing Agents with emphasis on 8% copper naphthenate and other chemicals with respect to Government specifications.

* * *

Sutherland Refiner Corp., Broad Street, National Bank Bldg., Trenton, N. J., has issued a new catalog on "Modern Stock Preparation with Sutherland Continuous Beating Systems."

* * *

The General Electric Co. Special Products Digests for January, 1952, and Descriptive Leaflet-685 describes the new G.E. Paper Tensiometer used at P.H. Glatfelter Co.'s mill at Spring Grove, Pa. Use of this device is claimed to reduce the number of paper breaks of paper passing through calender rolls.



Paper Tensiometer installed between second calender and reel on a paper machine at P. H. Glatfelter Co., Spring Grove, Pa.

In operation, the 4-inch roller on the tension head rides on top of the moving sheet so that a slight "dimple" is depressed into the sheet. Variations in the sheet tension change the air gap of a magnetic structure inside the device which emits an electric signal proportional to the paper's tension. This is transmitted through the power unit which contains the metering circuits, indicating instrument, and operator's control.

Carl A. Salmonson has been appointed General Manager of General Electric's newly formed Industry Control Dept., at Schenectady, N. Y.

* * *

Magnus Chemical Co., Garwood, N. J., has announced Magnus 751, a new cleaner for the removal of carbonaceous deposits from the tubes of fuel oil heaters, without need for dismantling the equipment. Instead of removing fouled tubes, cleaning is accomplished by exposing the deposit on the tubes to the action of 751.

* * *

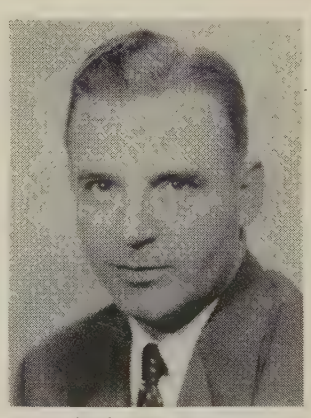
H. N. Hill & Co., Philadelphia 29, Pa., has issued a new bulletin (1151) on "Hilstrip Seams for Dryer Felts."

* * *

Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio, has issued a bulletin (BG-1) on its Beta-Ray Gage. This device is designed to measure moving sheets of material with great accuracy.

* * *

Ray E. Harroun, West Coast Sales Manager of the A. E. Staley Mfg. Co., has been promoted to the position of Assistant Manager of the Company's Sales Dept. at Decatur, Ill.



R. E. Harroun, A. E. Staley Mfg. Co.

W. N. Dulaney, A. E. Staley Mfg. Co.

William N. Dulaney has been named Manager of Staley's Southeastern Sales Office at Atlanta, Ga.

* * *

E. I. du Pont de Nemours has announced the appointment of three members of the Dyestuffs Div. to new sales posts. C. Harrell Asbury was named Assistant Manager for Domestic Sales; Heinz A. Lips was appointed Manager of Lakes, Paper and Leather Section; and Kenneth C. Johnson, Manager of Textile Section.

Jack B. Callaway has been named Manager of West Coast Sales for the Pigments Dept.

W. Roger Stoll has been appointed West Coast Manager of du Pont's Electrochemical Dept. His headquarters will be at Elmont, Calif. His father, William R. Stoll, was West Coast Sales Manager for 30 years.

* * *

Morden Machines Co., Corbett Bldg., Portland, Ore., has issued a new booklet on the Morden Stock Maker. A feature of this booklet is a unique "transart" presentation in the centerfold, by means of which the internal construction of the Stock Maker is shown.

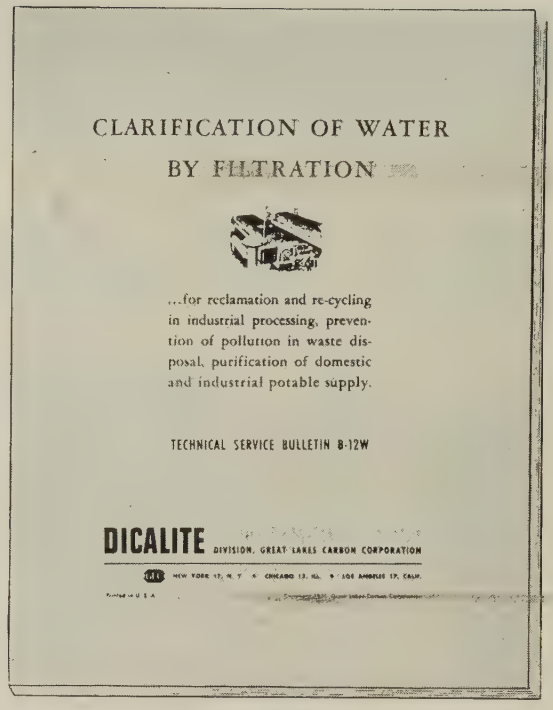
* * *

Downingtown Manufacturing Co., Downingtown, Pa., has

Two New Technical Bulletins for PAPER MILLS

USE OF DICALITE PAPER-AIDS IN THE FURNISH

BULLETIN F-52—Newly revised. Describes Dicalite diatomaceous paper-aids, giving the chemical and physical properties. Methods of adding to the furnish, quantities ordinarily used for various types of paper, and results to be expected are explained in detail. A section is also devoted to white water filtration using Dicalite filteraids.


CLARIFICATION OF WATER
BY FILTRATION
...for reclamation and re-cycling in industrial processing, prevention of pollution in waste disposal, purification of domestic and industrial potable supply.
TECHNICAL SERVICE BULLETIN B-12W
DICALITE DIVISION, GREAT LAKES CARBON CORPORATION

DIATOMACEOUS FILTERAIDS FOR WATER FILTRATION

BULLETIN B-12W contains a section somewhat more complete than Bulletin F-52 on white water filtration, in addition to data on filtering other waters. It covers the general subject of filtration for reclamation and re-cycling water in industrial processing, prevention of pollution in waste disposal, and purification of domestic and industrial potable water supply.

DICALITE DIVISION, GREAT LAKES CARBON CORPORATION

GLC

NEW YORK 17 · CHICAGO 1 · LOS ANGELES 17

Write to: 612 S. Flower St., Los Angeles 17, Calif.

View of the super cutter from delivery end showing layboy at the starting position

issued a bulletin (Bull. 252) describing a new cutter being manufactured now in this country. This is a development of the Masson-Scott cutter and layboy which has been manufactured in England for a number of years.

* * *

The Diamond Alkali Co. has awarded contracts to H. K. Ferguson Co. to engineer and construct facilities for a major expansion of chlorine production at Painesville, Ohio. This expansion will more than double Diamond's productive capacity for chlorine and caustic soda by the electrolytic method. It will enable the company to abandon the traditional lime-soda process of producing caustic. This will make available to industry a large tonnage of soda ash, now used in making caustic soda.

* * *

Buffalo Electro Chemical Co. has recently brought in a new peroxide plant at Vancouver, Wash.

DuPont is putting up a new peroxide plant at Memphis, Tenn., which should be completed by the end of this year.

* * *

The International Nickel Co., 67 Wall Street, New York, N. Y., has issued a new booklet on "Rapid Identification of Some Metals and Alloys." This should be of value to companies participating in the metals scrap drive.

* * *

The first successful run of a papermakers' felt made of 100% synthetic fiber has been announced by F. C. Huyck & Sons, Albany, N. Y. The felt was run in the Camas, Wash., mill of the Crown Zellerbach Corp. on a high-speed Yankee fourdrinier machine making lightweight papers. Its life substantially exceeded the average on this position and it gave free drainage throughout its life with no evidence of filling.

Since the earliest days of papermaking, wool fibers have been used to make papermakers' felts. Until recently, wool appeared to be the only fiber providing the peculiar characteristics needed for this purpose. For the past few years, felts have been made with a combination of wool and synthetic fibers, but it now appears that all synthetic felts can be employed successfully for certain uses. While it is still too early to predict that the principles embodied in this felt will be universally applicable to all types of machines and grades of papers, Huyck research indicates that they can probably by applied in other conditions to advantage. Besides providing greater resistance to frictional wear as well as freer passage of water, the synthetic fiber is immune to attack by bacteria, a reason for short felt life in many mills.

* * *

N. D. Ellis has been made Director of the Packaging Engineering Dept. of Anheuser-Busch, Inc., St. Louis, Mo.

* * *

Freeport Sulphur Co., oldest sulphur-producing firm in the United States, has announced that it is spending approximately $20,000,000 on new projects to increase the nation's supply of defense-essential sulphur. During the year the Company:

1. Acquired new reserves of sulphur in salt dome deposits and in other forms.
2. Started development in the Louisiana marshes of new brimstone mines at Bay Ste. Elaine and Garden Island Bay.
3. Produced 1,560,000 long tons of sulphur to approximate the record output achieved in 1950.

A third new mining development will be undertaken at Nash dome, about 35 miles southwest of Houston, Tex., where drilling has established existence of a small brimstone deposit.

As part of a long-range program to bolster reserves and broaden the earnings base for the future, rights were obtained on Government lands near Carlsbad, N. M., as a potential source of potash, and on lands containing sulphur-bearing ores, including 7800 acres in Carroll County, Va., and exploration for and development of oil and gas were continued.

Existence of a substantial deposit of potash, used principally in fertilizer, has been established by prospect drilling on the Government lands in New Mexico, it was said, but further drilling and study of the potash industry will be undertaken in order to determine future action. No development of the Virginia pyrites deposits is planned at this time.

Production of 1,272,000 long tons of sulphur at Grande Ecaille, first major marshland deposit ever to be developed, was the highest on record, according to the report, but production at the company's Hoskins, Tex., mine declined to 284,000 tons.

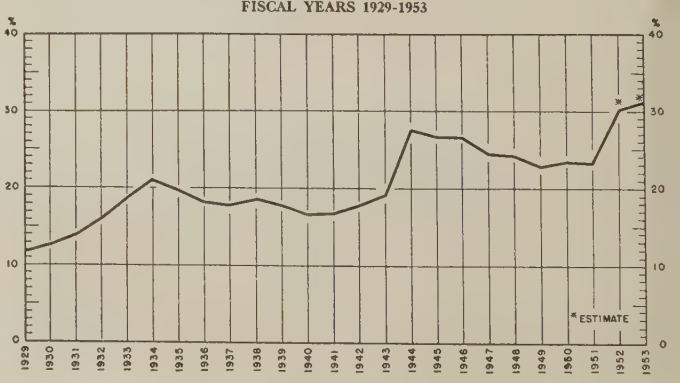
Grande Ecaille, producing almost four times as much sulphur as it did prewar, has reserves "sufficient to permit production at the present rate for a long time to come," the company said, while Hoskins, oldest Gulf Coast salt dome mine in operation, is nearing exhaustion.

Discussing the world sulphur shortage, Freeport says that the outlook is improving. Although 1951 was a year in which the demand for sulphur throughout the free world continued to exceed the supply, the shortage has acted as a stimulus to new projects designed to increase the amount of sulphur.

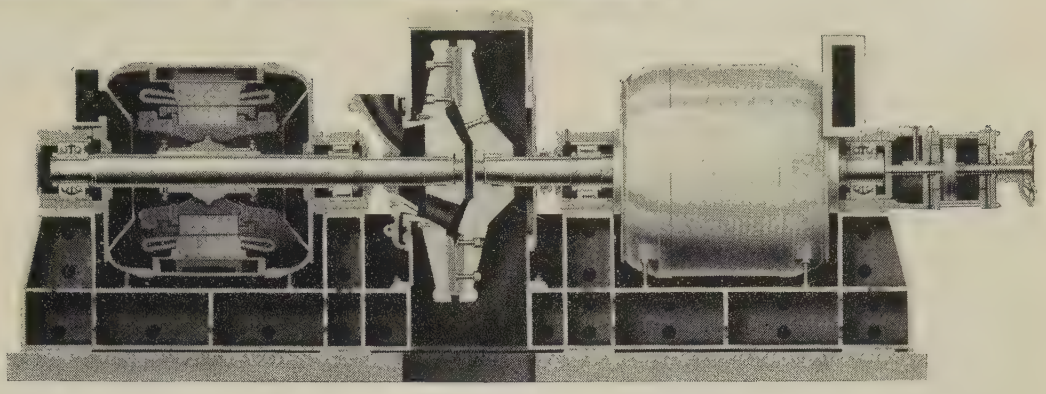
It is estimated that, by the end of 1953, the annual output in the U. S. may be increased by 1,200,000 long tons of brimstone and about 50,000 long tons of sulphur in various forms from other sources while 1,300,000 tons more per year may be realized from projects in other countries.

RATIO OF TOTAL TAXES TO NATIONAL INCOME

FISCAL YEARS 1929-1953



for best fiberizing and dispersion



BAUER 40-IN. NO. 410 DOUBLE-DISK PULP REFINER

This is the largest double-disk pulp refiner now available. It is designed to use 600 hp effectively. Refining pressures and disk gap settings are regulated by finger-tip, pneumatic control. Disk adjustment is in increments of .001 in.

Bauer Pulp Refiners are used in pulp and paper mills throughout the world for fiberizing, dispersing, deflocking, and size reduction. Their preponderate usage is proof of the superior work they are doing.

To get complete information and data on the 400 series of Bauer Disk Refiners, ask for a copy of Bulletin P-2. A request for the bulletin will not expose you to a solicitation. However, if you desire information on your own specific problems, our sales engineer in your area will be glad to consult with you.

Write, wire, or phone.

272 BAUERS in use today on semi-chemical jobs alone

Four of the nine Bauer Refiners in a board mill where these machines do all the refining on semi-chemically cooked chips.

Bauer

THE BAUER BROS. CO.

1715 SHERIDAN AVE. • SPRINGFIELD, OHIO

OBITUARIES

Bourdon Walter Scribner

Bourdon W. Scribner, Chief of the Paper Section, National Bureau of Standards, Washington, D. C., died on March 5, 1952, in Washington from a heart condition aggravated by asthma.

Mr. Scribner was born in Ridgeway, Pa., on Nov. 21, 1884, and graduated in chemistry from Pennsylvania State College in 1908.

Bordon W. Scribner

Following graduation he went with the West Virginia Pulp and Paper Co. at Piedmont, W. Va., where he remained for 13 years as director of the laboratory. He then joined the staff of the Paper Section of the National Bureau of Standards in Washington and became Chief of the Section in 1923.

At the Bureau he directed researches dealing with papermaking problems, improvement of offset printing, preservation of records, standardization of paper and paper testing methods, and the development of testing procedures and instruments. He was a Chairman of the Committee on Federal Specifications and an Advisor to the Joint Committee of Congress on Printing.

Mr. Scribner became Chairman of the Paper Testing Committee of the Technical Association of the Pulp and Paper Industry in 1925 and initiated the systematic development and adoption of testing standards by the Technical Association.

The aggressive pioneer work of Mr. Scribner and his associates in developing the basic paper testing methods which did so much to bring about an ever-increasing improvement in the quality of paper and paperboard manufactured by the industry and converted into useful paper products led to the award to him by the Technical Association of the Pulp and Paper Industry of the industry's highest award, the TAPPI medal.

Williamson Glover Brasfield, Jr.

Williamson Glover Brasfield, Jr., Assistant Superintendent of the Pulp Mill of the Union Bag & Paper Corp., Savannah, Ga., died on Feb. 14, 1952, in a Savannah hospital following a short illness.

Mr. Brasfield was born in Demopolis, Ala., on Dec. 3, 1909, and graduated as a chemical engineer from Alabama Polytechnic Institute in 1933.

From 1934 to 1936 Mr. Brasfield was a laboratory assistant for the Alabama State Highway Dept. From 1936 to 1940 he worked in various positions for the Southern Kraft Corp. at Panama City, Fla. He was a Lt. Colonel in the United States Army from 1940 to 1945 and joined the Union Bag & Paper Corp. organization in 1945 as a chemical engineer.

Funeral services were held on February 15 at the First Presbyterian Church in Savannah. The body was sent to Eufaula, Ala., for interment. Mr. Brasfield is survived by his wife, Mrs. Marian Luke Brasfield; his mother, Mrs. Annie Hardy Brasfield of Demopolis; two sons, Williamson Glover Brasfield, Jones Ernest Brasfield; one daughter, Luke Brasfield; and one sister Mrs. Joe Sarver, Jr., of Auburn, Ala.

Mr. Brasfield was an active member of the Technical Association of the Pulp and Paper Industry.

John Frank Halladay

John Frank Halladay, Consultant, died suddenly at his home in Elkhart, Ind. on Thursday, March 27.

Mr. Halladay was born in Battle Creek, Mich. on July 22, 1901, the son of Frank E., and Jennie Louise (Himsicker) Halladay, and attended the University of Pennsylvania. In 1928 he joined the Michigan Carton Co. as a salesman. From 1929 to 1940 he was employed in the Chicago, Wabash, and Manayunk mills of the Container Corp. of America in the printing and box-making departments.

In 1940 he joined the American Coating Mills at Elkhart, Ind. and in 1946 he established his own business as a consultant in the field of papermaking coating and board converting.

Mr. Halladay was a member of the Technical Association of the Pulp and Paper Industry and the A.P.P.M. Superintendents Association.

He is survived by his widow, the former Harriet Grandin, one son, John Frank, Jr. of So. Pasadena, Calif. and one granddaughter.

Leo J. Rioux

Leo J. Rioux, Sulphite Mill Superintendent for Fraser Companies Ltd., Edmundston, N. B. died on March 13 at Edmundston.

Mr. Rioux was born at Rimouski, Que. on October 24, 1897. He joined Fraser in 1918 as a millwright. In 1930 he was appointed Asst. Superintendent of the pulp mill of the Restigouche Co., Ltd. at Atholville, N. B. He returned to Edmundston in 1933 as Superintendent of the Sulphite Mill, which position he held at the time of his death.

He is survived by his wife, two daughters, two brothers, and five sisters.

Mr. Rioux was a member of the Technical Association of the Pulp and Paper Industry, Tech. Section, C.P.P.A., A.P.P.M. Superintendents Association, and Rotary Club. Interested in civic affairs he served as a member of the Edmundston Town Council from 1941 to 1945.

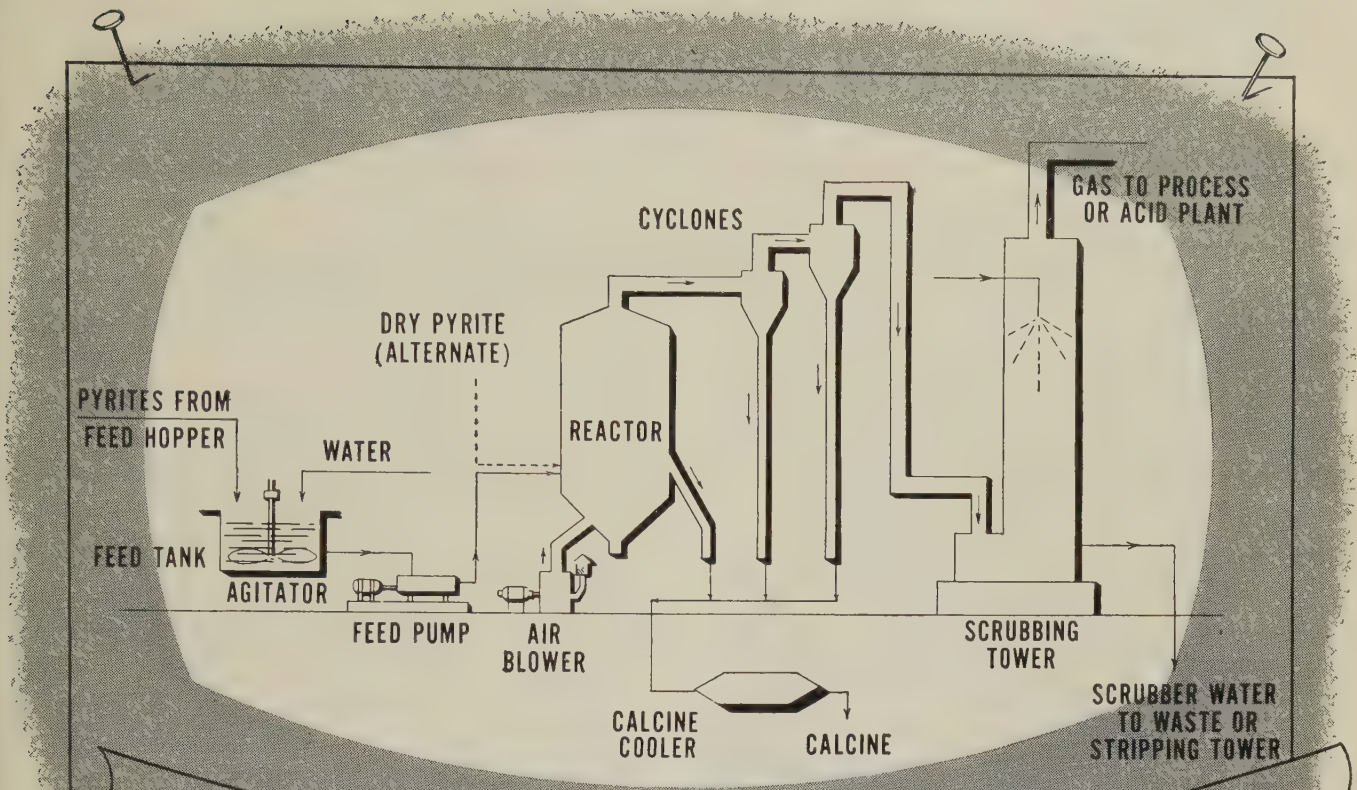
Surrey W. Slater

Surrey W. Slater, Consultant, died at Lufkin, Tex., on Dec. 19, 1951.

Mr. Slater was born in New York City on Feb. 4, 1885, and graduated as a mechanical engineer from Stevens Institute of Technology in 1908.

He joined the Consolidated Paper Co. in Quebec in 1918, remaining until 1940 as Division Manager. In 1940 he became General Manager of the Southland Paper Mills at Lufkin, Tex. During the two years prior to his death he was acting as a consultant to the pulp and paper industry.

Mr. Slater is survived by his widow, Mrs. Elizabeth Slater, one son and daughter of Lufkin, Tex., and a daughter, of E. Orange, N. J., by a previous marriage.



Now...HIGH STRENGTH SO_2 for sulphite pulp production...

Dorrco FluoSolids* System gives you 14-15% SO_2 from 48-50% pyrite 12-13% SO_2 from 35% pyrrhotite

Sulphuric acid manufacturers and all users of sulphur dioxide faced with a shortage of elemental sulphur are finding in FluoSolids an economically feasible means of tapping sulphides as an alternate source of SO_2. In sulphite pulp mills alone, eight Dorrco FluoSolids Systems are now being installed.

For detailed information about FluoSolids — a distinct departure from conventional roasters — ask for a copy of Dorrco Bulletin No. 7500. Just write to The Dorr Company, Stamford, Conn., or in Canada, The Dorr Company, 80 Richmond St. West, Toronto 1.

*FluoSolids is a trademark of The Dorr Company Reg. U.S. Pat. Off.

Facts on FluoSolids Systems for SO_2 Production...

Gas Strength will average 14-15% SO_2 dry basis from pyrite carrying 48-50% sulphur, and 12-13% from pyrrhotite carrying 35% sulphur.

Gas Cleaning Equipment is smaller than with conventional methods.

Feed can be relatively coarse — or can be wet.

Low Maintenance because no moving parts are exposed to high temperatures.

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TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Engineering Division

The Engineering Division had a full afternoon meeting on February 18 and even then could not complete all of the items on Mr. Sibler's agenda. The attendance was around 50, an excellent response.

Most of the time was devoted to reports of individual committees regarding their program for the Chicago meeting. Judging from the topics selected, the Chicago program is well rounded and should be of interest to a wide circle of engineers. Nearly all committees have their program practically completed.

In addition to our general meeting, several committees and subcommittees held individual meetings during the convention week.

Mr. Pringle talked to us on TAPPI projects and encouraged committees to do more on fundamental research and contribute more information on Data Sheets. He stated that money is available for such use.

Mr. McNally gave us a brief report on the plans for the coming Chicago meeting. One point he mentioned which would be of interest to many foreign visitors is a rule regarding tours; because of *Government* restrictions—not individual plant requirements—noncitizens must submit their request for plant visits 30 days in advance. Perhaps we will get the clarification of this later to include in *Tappi*.

Toronto, Canada, was selected for the 1953 meeting.

W. C. Bloomquist, *Secretary*
TAPPI *Engineering Division*
Schenectady, N. Y.

Hydraulics Committee

The Hydraulics Committee met in Room D of the Commodore Hotel, New York City, at 2:00 p.m., Tuesday, Feb. 19, 1952, during the Annual Meeting of TAPPI, with the following members present: K. J. Mackenzie, Chairman, J. P. Casey, Jr., V. deP. Gerbereux, George V. Shaw, F. R. Forrest, T. Agronin, Lyle C. Jenness, R. G. Quinn, F. W. O'Neil, and J. O. Starkweather.

This meeting was called for the purpose of crystallizing further work to be done on pipe friction loss at the University of Maine during the coming year under a TAPPI research grant.

For the benefit of the members not present at the Engineering Conference in Savannah in 1951, Mr. Mackenzie outlined the conclusions reached at the committee meeting at that time. These were that a modified shear tester, such as that described by Victor Head, should be built along with a one-pipe friction loss system and an attempt should be made to correlate shear criterion with pipe friction.

Mr. Mackenzie then presented the detailed estimate of the cost of such a project as prepared by the Department of Chemical Engineering of the University of Maine. This estimate totaled $6275.

L. C. Jenness reported that his department has been in constant touch with Mr. Head during the winter and that the final design of a shear tester was well along.

At Savannah it had been tentatively decided that the pipe friction test setup should be an 8-inch pipe. Discussion developed the fact that this would require a 125-hp. motor for the pump and it would be necessary to bring in a special line and transformer for such a motor. It was finally agreed that the test setup should consist of a 60-foot length of 6-inch pipe with a test length of 40 feet. The return pipe should be 12 inches in diameter. This should reduce the power load below 60 hp. and allow for the use of a 60-hp. motor now on hand at the University of Maine.

Mr. Forrest reported that Allis-Chalmers have a large tank equipped with a high-density agitator directly connected to a pump of sufficient size to handle the volume and head required for this installation. The high-density agitator will work satisfactorily as a pulper. Allis-Chalmers will ship this equipment to the University of Maine on a loan basis for these tests. The high-density agitator will require a 25-hp. motor which will be loaned by the Eastman Kodak Co. Mr. Jenness will attempt to borrow the necessary pipe from paper mills in the vicinity of the University of Maine. If he is not successful the committee will attempt to locate it elsewhere.

In addition to measuring pipe friction, the setup will be so arranged that a series of manometer taps will be used to check the safe distance that a tap should be from an elbow.

As soon as the Research Appropriation Committee approves this research grant, work will get under way so that the test runs will be made during the coming Summer, with the expectation that the results can be presented at the Engineering Conference in Chicago next Fall.

K. J. Mackenzie, *Chairman*
TAPPI *Hydraulics Committee*
Rochester, N. Y.

Engineering Research and Machine Design Committee

The Engineering Research and Machine Design Committee held its usual luncheon meeting during the TAPPI Convention in New York. This luncheon was on Monday, February 18, in the South Room of the Commodore Hotel. Twenty-one persons including six guests were present. Guests included George Pringle, James Hemphill, R. G. Macdonald, Charles Sibler, Walter Bloomquist, Dwight Jones, and M. Strain.

After the luncheon a short period was devoted to the presentation of engraved silver cigarette boxes to George Pringle and "Bumps" Hemphill as tokens of the services they have extended to the committee. Donations for these boxes were from the members of the committee. A short discussion was held after the presentations on the program for the Chicago Convention in the Fall. This discussion was continued in the afternoon meeting of the Engineering Division of TAPPI.

In the afternoon session John Lyall presented the tentative Fall program of the Engineering Research and Machine Design Committee. This will include tentatively three papers for the regular session. These will be selected from the following four possibilities: the first approximate title is "Photographic Procedure for Measuring the Rate of Formation of a Sheet on a Cylinder Machine Using High-Speed Photography." This paper will come from Eastman Kodak and no author has been selected as yet. The second paper by Mr. Jackson of the St. Regis Paper Co. of Pensacola, Fla., has the tentative title "Method of Calculating Flows in a Vat Circle." J. B. Gough of the Mead Corp. of Chillicothe, Ohio has two possible contributions, namely, "Theoretical Approach for the Flow of Stock Through a Slice on a Fourdrinier" and

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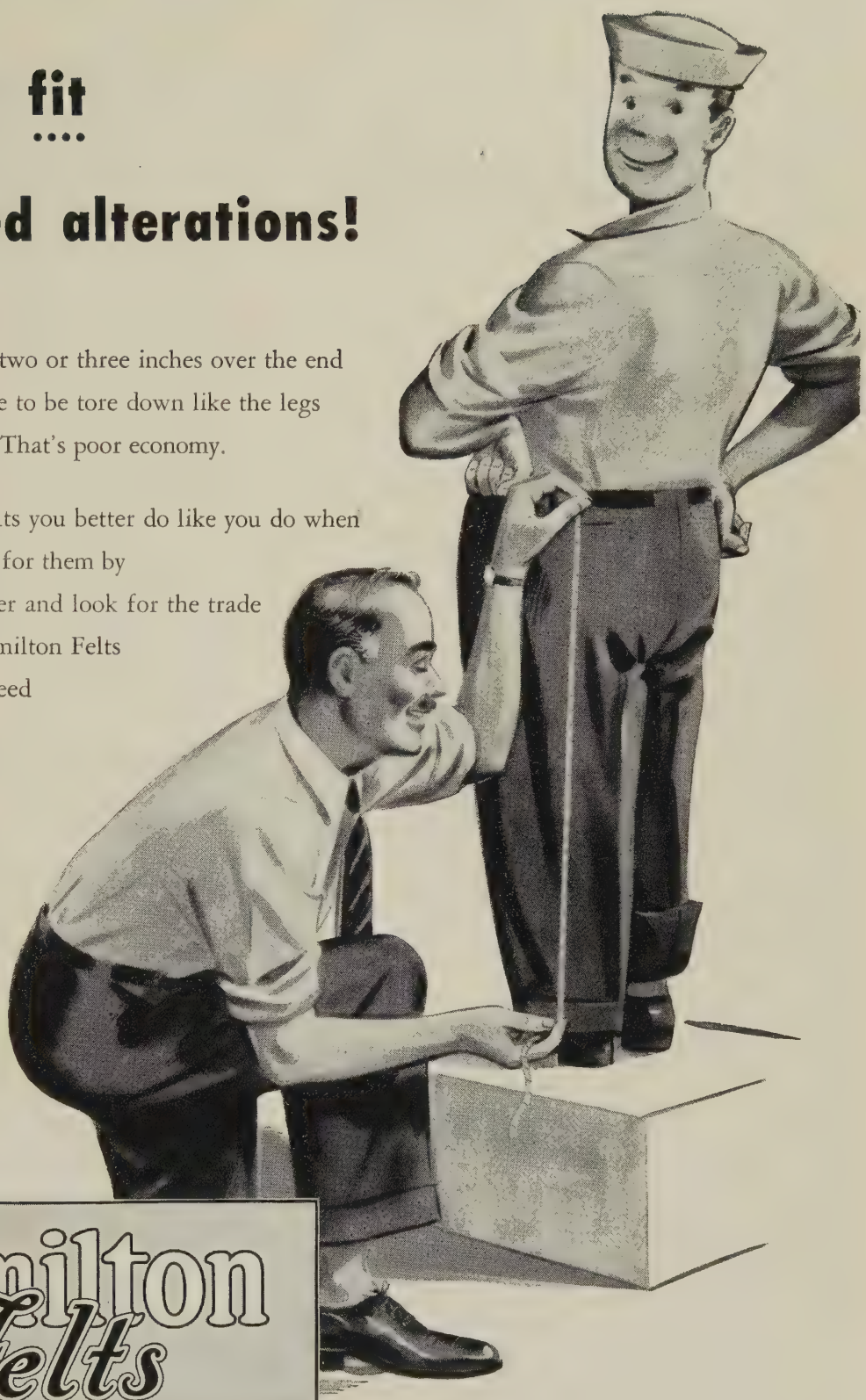

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"Theoretical Concept of Drying." Discussion will follow the papers and will also be carried into the afternoon round-table discussion.

Also to be included in the afternoon round-table meeting will be a discussion of "Methods for Estimating Pipe Costs." Mr. Ingraham, chairman of the subcommittee on cost estimating, has secured the cooperation of Mr. Dixon, who has recently written a book on estimating pipe costs and it is possible that Mr. Dixon might be at the Chicago meeting. Other subcommittees have not lined up definite programs as yet, although it is possible that some of them will have something to present at Chicago.

R. T. DePan, *Secretary*
Engineering Research and Machine Design Committee
Downingtown, Pa.

Electrical Engineering Committee

On Monday afternoon, February 18, the over-all Engineering Division held a meeting under the chairmanship of C. J. Sibler to discuss plans for the Chicago meeting in the Fall. This will be reported in *Tappi*, but the high lights are as follows:

1. Each committee reported on its schedule of papers for Chicago.
2. It was decided that the general sessions for each committee in Chicago should be $1^1/_4$ hours, to give time for suitable intermissions. Mr. Sibler emphasized that we should be very careful not to run over.
3. A plan for rotating the timing of the sessions over the years for each committee was given to us by Mr. Sibler so that everyone will have a chance at the most favorable spots on the program. This will be written up and circulated.

In addition to the foregoing, the question was raised by R. R. Baker about the procedure for submitting committee reports, and whether these should be made into TAPPI standards or data sheets. Mr. Sibler stated that a report would be considered as having committee approval if it were passed by a majority vote. In the case of our work on the Electrical Committee, Mr. Sibler explained that these reports were suitable for data sheets, rather than standards since the latter are used to cover procedures and the former, engineering "handbook" reference material.

There was a discussion of the Steam and Power Committee's plans for Chicago which may bear upon our activities in the Electrical Committee and should be mentioned here. The Steam and Power Committee plans to submit a report on turbine versus sectional electric drives. The Electrical Committee had some informal discussion on this at Savannah and in Mr. Foster's absence, the writer, as secretary, tried to represent our committee's point of view. It was pointed out that Mr. Roland Packard had submitted a series of two papers on the subject of lineshaft versus sectional drives which were descriptive in nature and that the next step should consist of a paper which would deal with performance records if it were to carry the subject further. The decision was not made in the general meeting as to what the Steam and Power Committee would do, but the Electrical Committee may want to set up a joint group with the Steam and Power Committee to get this performance information, and the writer will get in touch with Mr. Foster for his decision on this. These performance data should include records of down time and maintenance expense, as well as first cost, and we will have to have a standardized bookkeeping system.

Following the general meeting, the Electrical Committee held a short meeting of its own.

During this meeting plans for Mr. Mortenson's Cable Report were discussed and also Mr. Baker's Report on Power Requirements for Press Sections. Since Mr. Mortenson had so much ground to cover, Mr. Baker thoughtfully suggested that his paper be given after Mr. Mortenson's in the general session, and that he adjust his time accordingly. Since both of these papers will represent formal committee reports, it is hoped that we can get them in June or July for circulation within the committee.

We had scheduled tentatively in Savannah a paper on experience with grounded power systems for the general session, but it does not look as if we will have time for this, so with Mr. Foster's approval, it was decided to postpone it until 1953.

John Osborne is preparing a preliminary project report on the Power Requirements for Chippers, which will be given during the round-table session. Mr. Osborne has made an excellent start on this and considerable discussion took place on the procedure for getting power data during our committee meeting. It was decided to request information from the principal chipper builders and also from the electric motor manufacturers. In addition it was planned to try to get power data from 30 pulp mills. Mr. Osborne has this project very much in hand and you will be hearing from him from time to time.

We also had scheduled tentatively a preliminary report on Power Requirements for Supercalenders by J. L. Van Nort. However, the Chipper Report will have to cover so much ground that it is expected Mr. Van Nort's report will have to be postponed until 1953.

The meetings in New York were attended by the following members of the Electrical Committee: R. R. Baker, G. W. Knapp, A. O. Mortenson, M. J. Osborne, and M. Strain.

Unfortunately Ray Foster could not make the New York meeting because of a broken arm. We understand that it is coming along fine.

George W. Knapp, *Secretary*
Schenectady, N. Y.

Mill Maintenance and Materials Committee

With reference to the Engineering Division Letter No. 2, dated Feb. 8, 1952, the Mill Maintenance and Materials Committee is pleased to advise that it has invited Professor George Harper of the University of Illinois to submit a paper on the Engineer's Approach to Safety and has approached one of the rubber companies asking that a paper be prepared on the Care and Maintenance of Rubber-Covered Rolls in the Pulp and Paper Industry. These two papers will be used at the main session of the Chicago meeting. It is planned to have a round-table discussion on Tool Room or Store Room for Maintenance Tools. It is hoped that immediately after this committee meeting that invitations will be issued to mill men, one who has had experience with tool rooms, the other who has had experience with store room storage of tools; each to prepare a paper presenting the advantages and disadvantages in their system. These papers will be used as the basis for the round-table discussion.

At the Savannah meeting a subcommittee on lubrication was set up to work with the American Society of Lubricating Engineers on the Lubrication Problems of Pulp and Paper Mills. Several other subcommittees were set up to take care of the following projects.

Project 341, Pulp and Paper Mill Lubricants—Specifications. This project has been completed and turned over to Mr. Macdonald for publication in *Tappi*.

Project 342, Application Guide or Basic Specifications for Copper and Copper Alloys, Monel and Stainless Steel. The copper and copper alloys portion of this work has been completed. It is expected that the Monel and stainless steel portion will be completed by next Fall at which time it will be discussed in committee meeting.

Project 345, Training Procedure of Maintenance Department Personnel, Harry C. Moore, Chairman. Material is being gathered together by the committee.

Project 376, Screening Capacities of Different Types and De-

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signs of Screen Plates on Various Types of Stock, Henry W. Downs, Jr., Chairman. Material is being gathered together by the committee.

Project 377, Procedures for Grinding Rolls of Various Compositions and for Various Purposes. Material for this work is being gathered together.

Project 378, Compilation of a Check List for Mechanical Preventive Maintenance in Pulp and Paper Mills. Material which may be used on this project is gradually being accumulated.

Project 379, Compilation of a Check List for Electrical Preventive Maintenance in Pulp and Paper Mills, A. M. Cooper, Chairman. Material is being gathered by the committee.

Project 380, Tabulation of Protective Coatings for Use Against Corrosive Conditions at Pulp and Paper Mills, W. W. Henderson, Chairman. Material is being gathered by the committee.

B. L. Merriss agreed to take the chairmanship of the Maintenance Cost Committee while at the Savannah meeting. It is hoped that this committee will be able to assist the Canadian Committee with their work.

H. F. Parker, *Chairman*
Mill Maintenance and Materials Committee
Lock Haven, Pa.

Microscopy Committee

Two meetings of the Microscopy Committee were held during the recent TAPPI Convention. The first, held on Monday afternoon, dealt entirely with the revision of T 401, "Fiber Analysis of Paper and Paperboards." The final draft of this revised method should be completed and in the hands of the methods committee within the next few weeks.

A second meeting was held Wednesday afternoon at which time other projects of the committee were discussed. The following work was outlined for the coming year:

1. H. C. Koch is to prepare a procedure for microscopic analysis of filler to be presented as a proposed TAPPI Standard. This work is to be completed prior to the testing conference to be held this Fall.

2. The microscopical identification of nonfibrous materials other than filler is to be investigated to compile data needed to enlarge the proposed method for analysis of fillers to include all nonfibrous materials.

3. Information already submitted on the identification of synthetic fibers is to be studied by F. L. Simons and a suggested procedure written.

4. The revision of T 8 sm-40, "Species of Identification of Wood and Wood Fibers," is to be continued under the direction of Mr. Donofrio.

5. Sources of photomicrographs of nonwoody fibers are to be investigated in preparation of a revision of TN m-47, "Species Identification of Nonwoody Vegetable Fibers."

6. The study in preparation for the revision of the method for identification of dirt in pulp and paper is to be continued.

7. Work is to be started under the direction of F. L. Simons on a proposed monograph dealing with the uses of a microscope.

C. E. Brandon, *Chairman*
TAPPI *Microscopy Committee*
Dayton, Ohio

Nonfibrous Materials Testing Committee

The Nonfibrous Materials Testing Committee held a meeting on Monday, February 18, to discuss the results of the committee's activities during 1951 and to plan the program for 1952. During the year the committee functions mostly through the efforts of the various subcommittees organized to develop new testing procedures and to evaluate the existing testing procedures used for nonfibrous materials.

At the present time there are four principal subcommittees working on the development of new methods for the testing of nonfibrous materials. These are the subcommittees for starch, clay, enzymes, and casein. In addition, there are subcommittees organized to revise the existing testing methods for rosin and rosin size and for TAPPI method 615. A summary of the activities of the subcommittees of the Nonfibrous Materials Testing Committee is given below:

Starch Testing—Subcommittee Chairman, C. C. Kesler, Penick & Ford, Inc., Cedar Rapids, Iowa.

During 1951 the committee for starch testing undertook a survey by questionnaire to obtain expression from the consumers of starch in the paper industry of the measurements and procedures which would be of most value to them in their use of starch. The results of this survey were studied and tabulated by the committee and finally written up in the form of tentative standards. Instead of trying to incorporate all the procedures in one standard method, it was agreed that each individual procedure would be written up and submitted as a separate tentative standard. Nine procedures have been written up and are now ready for transmission for final approval. These methods are as follows:

Sampling starch and starch products
Moisture in starch and starch products
Ash in starch and starch products
Cold water-soluble matter in starch and starch products
pH value of starch and starch products
Foreign material in starch and starch products
Protein in starch and starch products
Viscosity of starch.

In addition to these proposed tentative standards, six routine control methods for measuring viscosity have also been suggested and have been written up.

The initial program set up for the starch committee has now been complete and no further work is planned for the immediate future for this committee. Later on, as the need for new procedures is indicated, further work may be undertaken.

Clay Testing—Subcommittee Chairman, C. G. Albert, Edgar Brothers Co., McIntire, Ga.

During 1951 the clay committee surveyed the paper industry by questionnaire to determine what was needed in the way of test procedures for the evaluation of clay. The results of this questionnaire have been analyzed and a suggested TAPPI method for the evaluation of clay has been prepared. This method as now written covers procedures for sampling, grit determination, disintegration test (for coating clays), free moisture content of clays, brightness of clays, particle size of clays, and viscosity of clays (for coating clays). The proposed method as now written is extremely lengthy, and it was suggested at the time of the meeting in February that each procedure be written up as a separate method, following the same plan of the starch committee. The committee is now busy rewriting these methods according to this plan.

The committee has reached general agreement on all of the above testing methods for clay, with the exception of the sampling procedure and the particle size determination. There was considerable discussion at the meeting regarding the best sampling procedures for clay shipped in various forms. The committee is now undertaking to write up separate sampling methods for clay shipped in bag, bulk, and liquid form.

There are two generally used methods for determining particle size of clay and these are the Casagrande method and the Bouyoucas method. Both of these methods are being used by different clay companies and different users of clay. The clay committee is now trying to write up one method which would embody the essential features of both methods of testing for particle size.

Enzyme Testing—Subcommittee Chairman, Alexander Frieden, Pabst Laboratories, Milwaukee, Wis.

During 1951 the subcommittee on enzymes formulated two methods for the evaluation of enzymes to be used in the paper industry. One method is based on the spectrophotometric

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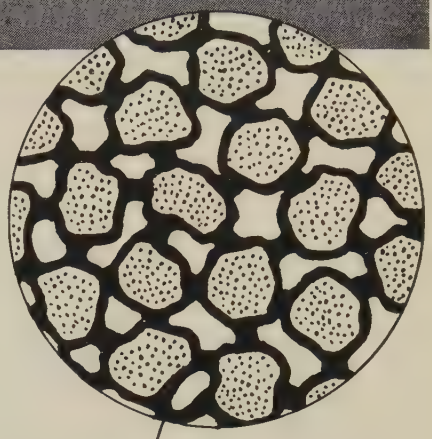

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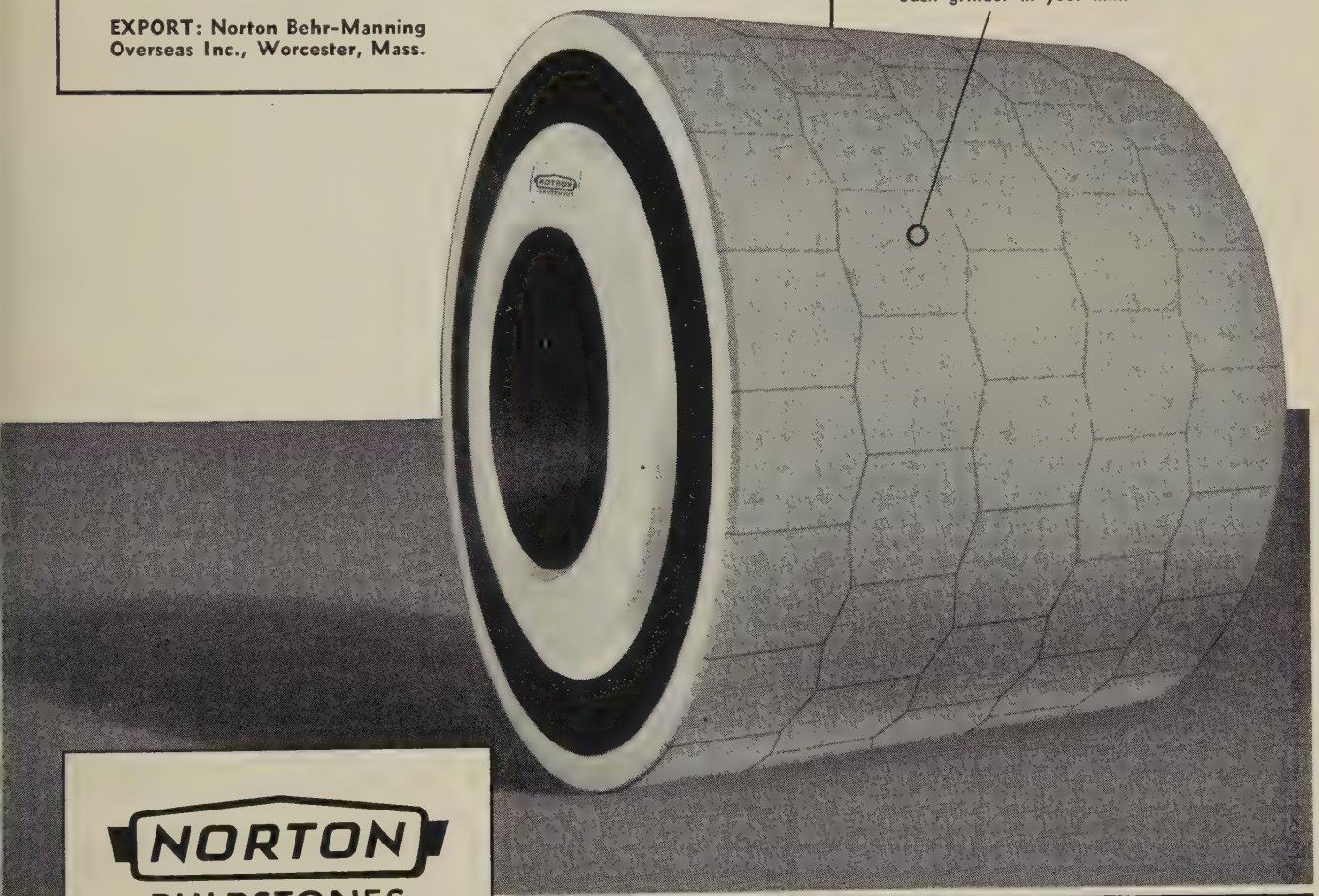

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determination of enzyme strength, and the other on the viscosity which is brought about in a starch solution by the action of enzymes. Both of these methods have been thoroughly studied by the various members of the subcommittee for the evaluation of enzymes. The two methods are now being written up in final form for a decision on the best method for TAPPI standards. A meeting of the subcommittee is planned at the time of the Coating Convention in Chicago in May, when it is hoped that a final decision will be reached. Soon afterward it should be possible to present a final recommendation of a method for the evaluation of enzymes.

Casein Testing—Subcommittee Chairman, D. B. Laird, The Borden Co., Bainbridge, N. Y.

A subcommittee has been formed to study the present TAPPI method for casein and to determine the need for revision. Three of the committee members have indicated that revision is needed and it is now planned to prepare a questionnaire to be sent to members of the coating industry to determine further what changes may be needed. The questionnaire should be prepared very soon and after the responses are in and have been studied, a revised method for casein will be prepared. It is hoped that a meeting of the subcommittee on casein can be held at the time of the Coating Convention in Chicago in May.

Rosin and Rosin Size Methods—Subcommittee Chairman, D. D. Cammeron, Hercules Powder Co., Wilmington, Del.

The revision of TAPPI Standard T 621 m-42, analysis of rosin, is now complete. This method has been worked up in accordance with the latest developments in ASTM and at the Department of Agriculture on the analysis of rosin. This method will be submitted for final approval in the very near future.

TAPPI Method T 628 m-43, analysis of rosin size, has still not been completed. Differences of opinion have been expressed regarding the best method of determining the free rosin content in rosin size. At present the committee is trying to resolve these differences and to establish a single method which will be acceptable to everyone concerned. Tests are being undertaken on the analysis of rosin size to determine the correlation which exists between different procedures. Every attempt will be made to reach a final conclusion within the near future and to make final recommendation for the submission of a revised method for the analysis of rosin size.

Revision of TAPPI Method T 615—Subcommittee Chairman, John Lewis, University of Maine, Orono, Me.

The present TAPPI method T 615 refers to clay as well as to calcium sulphate and other fillers and, since a new clay method will be ready soon, it will be necessary to revise T 615. It is planned to rewrite method T 615, leaving out all reference to clay and other fillers. Later on, it is hoped that this subcommittee, under the direction of Mr. Lewis, will undertake the writing of new methods for the analysis of other pigments not covered by existing TAPPI methods. The new method for calcium sulphate, T 615, will be written up very soon for submission for final approval at the same time that the clay method is submitted.

Method T 609 m-42-Method T 610 m-42. Lloyd Silvernail has been subcommittee chairman in charge of revision of several methods under the jurisdiction of the Nonfibrous Materials Testing Committee. Mr. Silvernail has resigned his chairmanship and at the present time this committee is not active. However, suggested changes for two methods have been proposed, T 609 and T 610. These suggested changes will be written up and circularized for approval of members of the Nonfibrous Materials Testing Committee. If a favorable vote is obtained, the suggested changes will be submitted for incorporation into the existing method.

New Projects—Nonfibrous Materials Testing Committee.

No new projects other than those discussed above are in the immediate plan for the Nonfibrous Materials Testing Committee. There is under consideration a project to prepare a new method describing sampling procedures which would be applicable to all nonfibrous materials used in the paper industry. If such a project appears worth while upon further consideration, an attempt will be made to organize a subcommittee to work on this project. Suggestions from members of TAPPI for other projects which might be undertaken by the Nonfibrous Materials Testing Committee will be appreciated.

J. P. Casey, *Chairman*
Nonfibrous Materials Testing Committee
Decatur, Ill.

Packaging Materials Testing Committee

The regular annual meeting of the Packaging Materials Testing Committee was held at 2 p.m. on Feb. 18, 1952, with nine members present, with an additional seven visitors. The committee participated in a general testing committee discussion under the chairmanship of Dr. James d'A. Clark, and the progress of the committee was outlined for the entire testing group.

The status of the approved projects was reviewed.

No. 275: Flexibility at Low Temperatures (Including Coating Materials, Tapes, Laminated Products, etc.). No action during the past year. This work is very closely related to that being done by the Joint TAPPI-ASTM Committee on Waxes, and it has been recommended that close liaison be maintained between the two groups.

No. 277: Water Vapor Permeability at Zero F. This subcommittee report was presented by L. E. Simerl, in progress report number 5. Data were presented from seven participating laboratories, and it was the consensus that the results were satisfactory. The proposed procedure will be written in TAPPI form as soon as possible.

No. 328: Flavor and Odor Transfer. Arthur Landrock, chairman of the subcommittee, will present a tentative organoleptic method, which will be available within the next two months. This will be based upon the use of a trained test panel. Further work must be done on the methyl furoate method using spectrophotometric analysis. Several questions were raised concerning this last method as proposed by General Foods, necessitating further consideration.

No. 331: Heat Sealability. This project is also closely allied to the work being done by the TAPPI-ASTM Committee on Waxes, and it is believed that methods now fairly well established in that field may be modified to cover the range interesting to the entire Packaging Materials Testing Committee.

No. 357: Water Vapor Permeability of Completed Package, at Various Temperatures and Humidities, With and Without Rough Handling. This procedure was divided into two sections several years ago. The first procedure, using any product and in packages of commercial sizes, will be rewritten by Charles Woodcock, chairman of the subcommittee, within the next few weeks. This procedure is ready for issue.

The second procedure, involving a standardized package size and using calcium chloride as the desiccant, is still in the development stages. At least one more round-robin check between laboratories is indicated.

In addition to the approved projects, two of the older standardized procedures have been under discussion for the last year.

T 473 m-47: Insect Resistance of Packages, Paper and Paperboard. Howard Gardner, chairman of the subcommittee, will present a revised procedure within a month.

T 464 m-45: Water Vapor Permeability of Sheet Materials at High Temperature and Humidity. Charles Southwick, chairman of the subcommittee, reported results from four laboratories who cooperated by returning data. The results were fair to poor, and additional work is scheduled with tighter control by the individual laboratories. It is hoped that additional technical groups will offer assistance.

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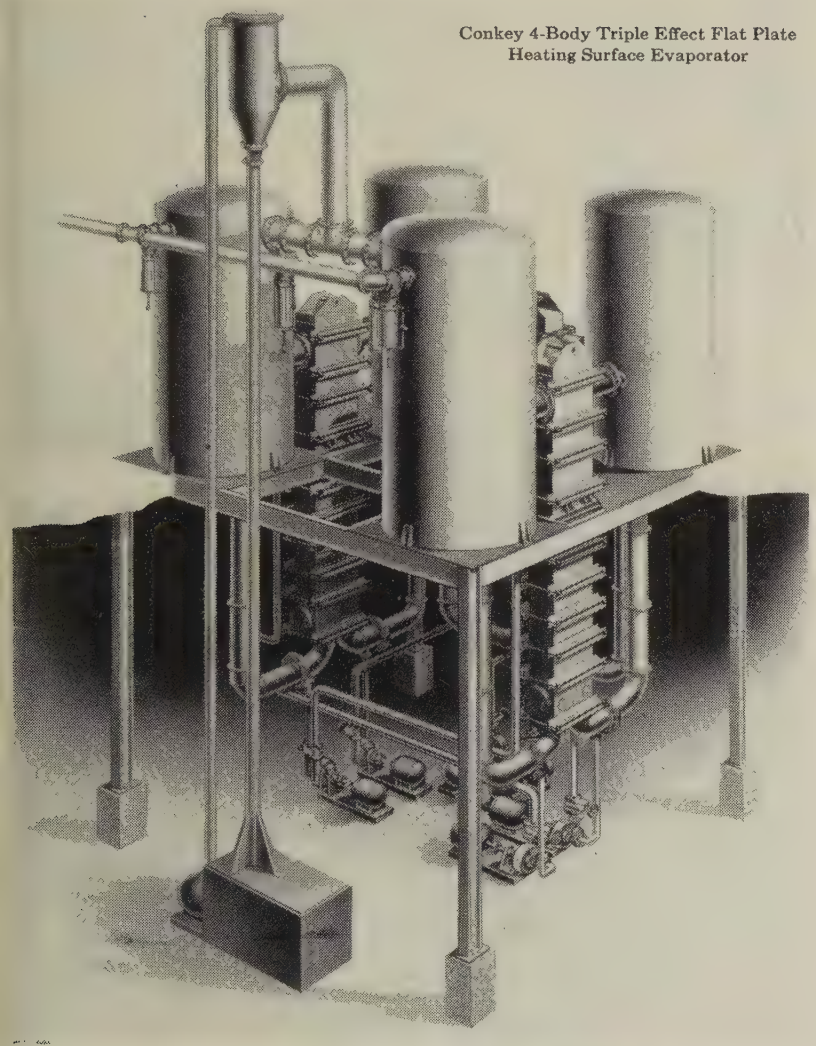

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A meeting was held of the chairmen of the committees of the testing division, and the methods of procedure for revising and instituting new methods are given here for the benefit of the entire committee. It is proposed that all methods be reviewed at least every five years, and that the task of rewriting be given to a separate subcommittee. The subcommittee may report that the method has been confirmed in its present state, and in that case the date of confirmation will be placed on the procedure.

If revisions are necessary, the revised method is sent by the subcommittee to the entire committee membership, with a note as to the nature of the revision, for a vote. Minor changes are also welcomed from the committee membership.

If the vote for approval by the committee is 50%, the method becomes a suggested method, and if the vote is 75% or over, then the method is tentative (see Bylaws Article XII). As soon as the vote and the suggestions for amendments are received, the amended procedure is then either sent out again for another vote, or if approved, one copy with the vote score is sent to the chairman of the Testing Division, James d'A. Clark. Dr. Clark will then review, amend as he feels necessary, and forward ten copies through the secretary to Roger Griffin, of the Standards Committee.

This committee now has several methods within a very few months of revision and acceptance. Please do all you can to expedite this work.

L. E. Simerl, *Chairman*
Packaging Materials Testing Committee

Optical Properties Committee

The following is a report of the delegation from the Technical Association of the Pulp and Paper Industry to the Inter-Society Color Council.

Most of the TAPPI delegates to the ISCC are also members of the Optical Properties Committee of TAPPI so this report is essentially an account of the activities of that committee. Since the writer assumed the chairmanship of this committee and of the TAPPI delegation during the past year, this report will be brief.

The committee submitted a tentative standard for "Specular Gloss of Paper at 75°" which was published in February of last year in *Tappi* as TAPPI Tentative Standard T 480 m-51. This method is recommended for measuring the gloss of coated book, waxed, or other shiny papers. For papers of low gloss, such as newsprint, bond, and writing papers, the older method of "Contrast Gloss of Paper at 57.5°" is more suitable. It is recognized that gloss is a complex property, and that further study of this subject is necessary. For mirror surface or very shiny papers no standard method has yet been proposed.

Fading resistance of papers is of importance not only as a measure of the fastness of the coloring materials, but also of the stability of the other materials used in making the paper. Thus it is in more than one way a measure of paper permanence.

In some mills fading tests are used in developing new papers or in control testing of the existing products. Some paper products fully meet the requirements with relatively low fading resistance, while others must have the maximum possible fading resistance because of the drastic use requirements. As a result fading tests have assumed a variety of forms, both as to type of equipment used and time of exposure. Any standard method for fading resistance must satisfy a wide range of testing conditions.

While considerable work has been done in an attempt to incorporate the NBS Light Sensitive Paper No. 1554 in a standard method for fading resistance of paper, certain inconsistencies in measurement and behavior of the fading equipment indicate that further investigation is necessary.

The Optical Properties Committee, in collaboration with the TAPPI Nonfibrous Raw Materials Committee, has for several years investigated the conditions necessary for a reproducible test for brightness of clay. Any method for brightness of clay or any other fillers hinges mainly on the sample preparation technique. The Nonfibrous Raw Materials Committee has arrived at a tentative procedure for clay sample preparation which possibly can be expanded to include other types of paper fillers as well.

A brief bibliography of articles on color and other optical properties of paper, covering the past year, is appended to this report. Particular attention is called to The Institute of Paper Chemistry Instrumentation Studies on the Densichron and Hunter Color and Color Difference meters. All references are given for the abstracts in the *Bulletin* of The Institute of Paper Chemistry (B.I.P.C.) as well as for the original articles.

H. E. Obermanns, *Chairman*
TAPPI, Optical Properties Committee, Erie, Pa.

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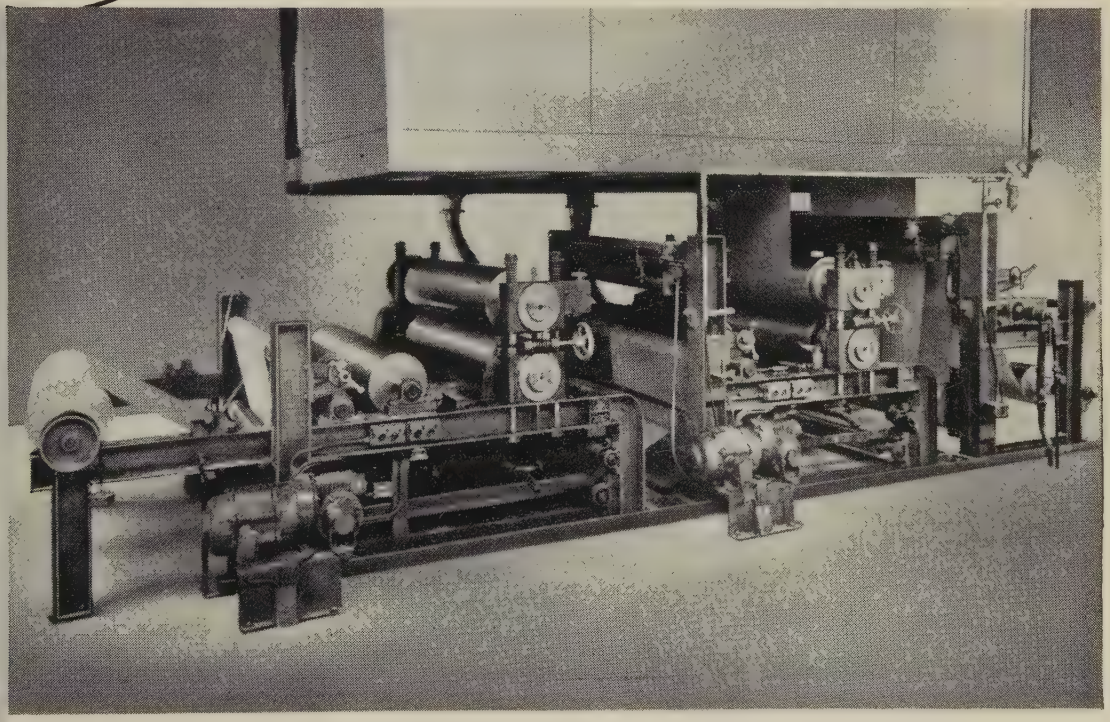

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Paper Testing Committee

On Feb. 8, 1952, there was a Paper Testing Committee meeting held in the Hotel Commodore, New York City.

D. H. Newcomb was appointed the new chairman of this committee following Mr. Warner's resignation.

Activities for the past year consisted of submitting the following methods to the Paper Testing Committee members for vote:

T 403 m-47—Bursting Strength of Paper
T 478 sm-50—Erasing Quality of Paper
Tensile Breaking Strength of Paper—Zero Span Method

These methods are almost ready for action by the Standards Committee.

The agenda for 1952 is as follows:

1. Pinholes in paper.
2. Blood resistance.
3. Revision of oldest methods.

Twelve committee members and guests took part in our active discussion of the testing methods for Bursting Strength, Blood Resistance, and Pinholes.

The Canadian Pulp and Paper Research Institute has done a considerable amount of work on the Mullen tester, especially with regard to the diaphragm plate and gages. New plates conforming to their new Standard Method which is being considered for adoption by this committee are now available from B. F. Perkins & Son, Inc., as well as the new Acragage which conforms with the new regulations.

Blood resistance testing of butcher wrap grades of paper was discussed. Some investigational work has to be done in order to obtain additional data before a standard testing procedure can be written. Some of the things to be studied would be the blood serum, ground beef, the fresh cut liver methods, and whether or not the specimens should be creased.

A standard testing method for determining pinholes was discussed briefly. A single test adaptable to all types of papers is desired.

D. H. Newcomb, *Chairman*
Paper Testing Committee
Milford, N. J.

Corrugated Containers Committee

The Corrugated Containers Committee, met on Monday Feb. 18, 1952, at the Hotel Roosevelt, New York, N. Y. Present were:

F. D. Long, Container Corp. of America
M. L. Hamilton, Container Corp. of America
M. W. Kaufield, Container Corp. of America
W. R. Tobin, American Box Board Co.
R. P. Aument, American Box Board Co.
M. F. Knack, River Raisin Paper Co.
J. Fuko, River Raisin Paper Co.
J. J. Koenig, Gaylord Container Corp.
W. W. Marteny, National Container Corp. of Wisconsin
H. T. Scordas, Union Bag & Paper Corp.
E. P. Whitener, International Paper Co.
Keith Max, Robert Gair Co.
L. K. Burnett, Ohio Boxboard Co.
B. Mendlin, Cornell Paperboard Products Co.
D. Martin, Cornell Paperboard Products Co.

Adhesive Questionnaire

There was considerable discussion as to what further use the committee should make of the data collected on the Adhesive Questionnaire. It was brought out that these data could be used as the basis for a special report to TAPPI or for a monograph. In connection with the actual writing of either of these, the help of interested suppliers could be used. It was also mentioned that discussions as to variations in formulas and discussions of the things that some companies do differently from the majority might form an interesting basis for discussion groups and for write-ups to be distributed in the form of special reports or a monograph. It was agreed that the Adhesive Subcommittee would give consideration to what might be done with the data available and report back to the Steering Committee. It was the feeling of the Steering Committee, however, that it would be desirable to issue the special report as a minimum use of the material.

Combiners Questionnaire

The method of analysis of the data in the Combiners Questionnaire was discussed. It was agreed that Messrs. Koenig, Johnston, Tobin, Scordas, and Mendlin would form a Task Committee to set up the form in which the results are to be compiled. They were to give this information to Des Long during convention week and he has agreed to have the compilation made by his people.

The Fall meeting at which the results of the Combiners Questionnaire are to be presented was discussed. It was the consensus of the committee that Milwaukee would be a desirable place for this meeting since there were several plants there which Corrugators would like to visit. It was further agreed that the same committee named above would act for the Corrugated Containers Committee in planning this meeting. The meeting may or may not be planned in conjunction with the Chicago section and may or may not be planned as a divisional meeting under the sponsorship of National TAPPI. Final arrangements are to be made in the near future between the Task Committee and Messrs. Long, Mendlin, and Burnett.

Stitching Questionnaire

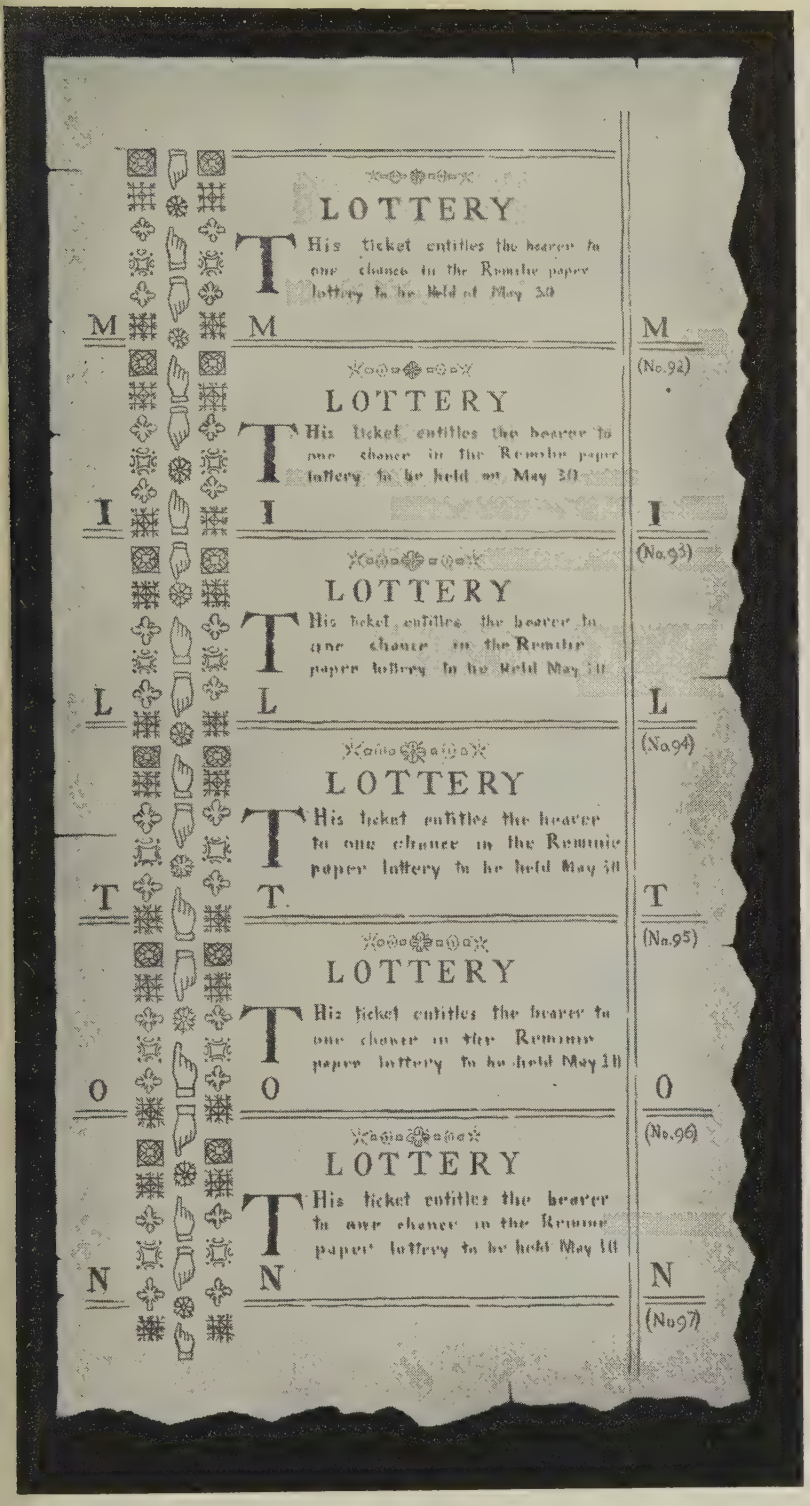
Mr. Marteny reported that the Stitching Questionnaire was practically ready for final approval and distribution. After some discussion it was decided that the questionnaire would be set up to cover several types of stitchers and that certain other minor changes suggested would be made. The questionnaire will then be ready to be incorporated with the Taping Questionnaire and sent out at a time to be selected by the committee. Mr. Marteny was requested to compose a letter to go with this questionnaire explaining exactly what the objective was and some of the details of how the committee would like the questionnaire filled out.

Taping

Mr. Whitener reported that the Taping Questionnaire was progressing satisfactorily and said that he believed it could be finished by May 1. It was agreed that Whitener and Marteny would work together on compiling the Stitching and Taping Questionnaire into a Finishing Questionnaire.

Waste Questionnaire

Mr. Max distributed copies of the first draft of a Waste Questionnaire which had already been sent out to his subcommittee members. He said that he would welcome criticism from any of the Steering Committee members and believed that he could have the questionnaire in final form by May 1. It was the feeling of the committee that the Waste Questionnaire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In 1782 the Milton Mill in Massachusetts needed money badly, and got official permission to run a lottery . . . another example of the resourcefulness of paper makers.

Difficulties of one kind or another always seem to have been the unwanted guests of paper manufacturers. Theirs has always been a constant struggle to improve the utilization of men, materials and machinery, to meet an ever-increasing demand for paper.

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should be the next one to be distributed since the subject is very timely and that every effort should be made to get this in the mail by the middle of May at the latest.

Printing Questionnaire

Mr. Hamilton reported that he had had some trouble securing cooperation from his subcommittee members. It was suggested that McNelly be added to this subcommittee. Mr. Hamilton agreed to make one more attempt to secure help from the present members of his committee, plus Mr. McNelly, and to come up with a completed questionnaire by May 1.

B. Mendlin, *Secretary*
Corrugated Containers Committee
Milwaukee, Wis.

Fibrous Agricultural Residues Committee

The Fibrous Agricultural Residues Committee met at the Commodore Hotel, New York, N. Y., on Feb. 18, 1952.

The activities of the committee for 1951 were reviewed briefly by Dr. Aronovsky. No Fall meeting was held last year.

The possibility of developing a research project to be carried out with TAPPI funds was discussed. It was pointed out that the project submitted in 1951 was too broad and vague and not sufficiently specific to warrant allocation of such funds for this work. After considerable discussion of the research needs of the strawboard industry, the committee members present agreed on a project to investigate processes or methods for producing high yields of straw pulp comparable with those obtained in semichemical pulping of wood. The committee chairman appointed a special subcommittee, consisting of C. G. Krancher, R. F. Burns, G. A. Zinkil, W. H. Palm, and L. E. Eberhardt, to draw up an outline of the project.

This special group reported on February 20, recommending that the proposed work be divided into two phases: (1) make a critical review of the methods for straw pulping, and (2) develop methods for producing the highest possible yields of straw pulp, consistent with high crush resistance of corrugating paper made from such pulp and good runability of the sheet in the corrugating plant. It was suggested that this project be carried out at The Institute of Paper Chemistry, Appleton, Wis., and that the Institute be contacted to give a preliminary estimate of the cost involved.

The desirability of a Fall meeting of the Fibrous Agricultural Residues Committee for 1952 was discussed. It was pointed out that a large proportion of this committee and other TAPPI members in the strawboard industry generally do not attend the Annual TAPPI Meeting in New York. It was also brought out that attendance at previous Fall meetings in mill cities and in Peoria drew a considerable number of men on the technical and operating staffs of the strawboard industry. The committee as a whole was heartily in favor of continuing the Fall meetings. Three possible mill sites for the 1952 meeting were suggested, but it was found that they would not be available for the Fall meeting. It was decided, therefore, that this meeting will be held at the Northern Regional Research Laboratory in Peoria, sometime in late October or early November, 1952.

The committee was of the opinion that the program of the Fall meeting should be a round-table discussion on "straw specifications and grading." It was also suggested that any remaining discussions on "straw pulping and processing," not covered in the present round-table session, should be included in the Fall program. As a basis for the round-table discussion at the Fall meeting, suggestions and questions will be circulated within the committee and the strawboard industry as a whole.

No reports of the subcommittees were given at this time. Eighteen TAPPI members attended this committee meeting and 14 of them were members of the committee. R. W. Kumler, Chairman of the Industrial Division of TAPPI, sat in on the discussions during part of the meeting. Those present were S. I. Aronovsky, R. F. Burns, N. H. Carpenter, W. L. Cassiday, J. W. Dow, L. E. Eberhardt, J. Fuko, F. Grunwald, M. F. Knack, E. Knapp, C. G. Krancher, E. C. Lathrop, J. R. Little, D. L. Owens, W. H. Palm, R. A. Springer, A. E. Teyral, and G. A. Zinkil.

A round-table discussion on Straw Pulping and Processing was held on February 21. The moderator of this session was M. F. Knack. A very lively discussion was held for about 3 hours on the following subjects: raw materials, cooking, stock preparation, and papermaking. Considerable interest was shown by the approximately 50 persons present at this meeting, and a large proportion of this group actively participated in the discussion.

The proceedings of this technical session were recorded by the stenotypist. The transcription of the discussions will be sent for correction to those participating, and the final report will be published in *Tappi*.

S. I. Aronovsky, *Chairman*
Fibrous Agricultural Residues Committee

Wet Strength Committee

The Wet Strength Committee held its 22nd meeting at the Hotel Commodore, New York, N. Y., on Feb. 18, 1952, at 2:00 p.m.

The following members and guests were present at this annual meeting:

K. W. Britt, Chairman, Scott Paper Co., Chester, Pa.
I. J. Gruntfest, Rohm & Haas Co., Philadelphia, Pa.
John Weidner, Container Corp. of America, Philadelphia, Pa.
R. R. Chase (Representing Dr. Charbonnier of Union Bag and Paper Corp., Savannah, Ga.
John R. Galloway, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
R. G. Hart, Casein Co. of America, Bainbridge, N. Y.
John B. Davidson, Plaskon Div., L-O-F Glass Co., Toledo, Ohio
Eugene Kane (Thomas J. Lipton, Inc.)
C. S. Maxwell, American Cyanamid Co., Stamford, Conn.

The first order of business was to reach agreement on the order of presentation of papers at the Wet Strength Session.

As a matter of record it should be mentioned that the above sessions went on as scheduled. The five papers were presented to a group of several hundred. The round-table session was crowded with about 35 participants who discussed all the questions previously submitted in answer to our questionnaire, plus other questions raised during the session.

The proposed wet strength monograph, the outline of which was published in the August, 1951, *Tappi*, is slowly taking shape. In addition to the previous assignments (minutes of the April 26 and June 27, 1951, Wet Strength Committee meetings) the following were made:

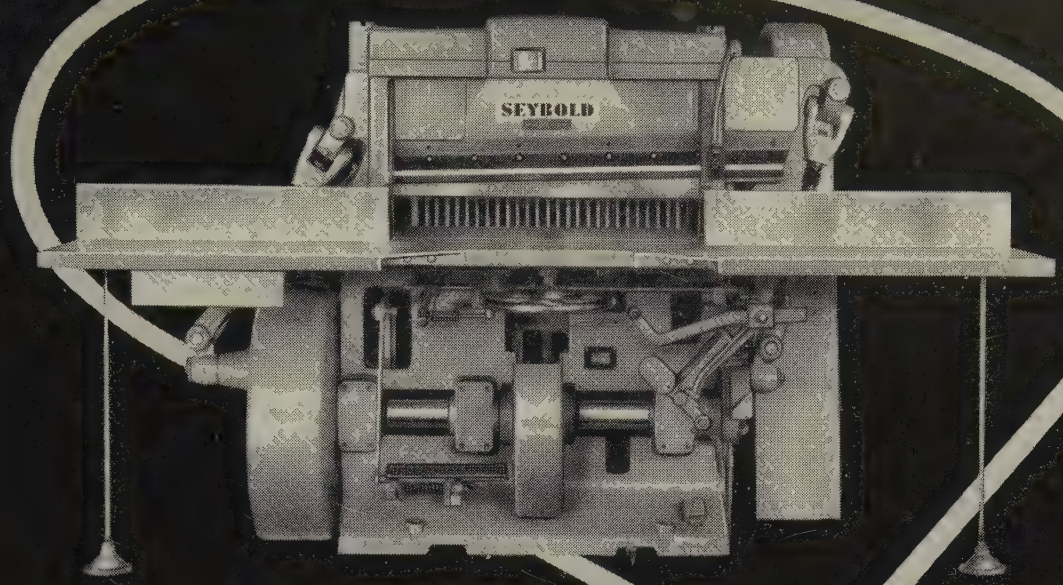
Part III Operating Procedures—J. B. Davidson
Part VII Market Evaluation—R. G. Hart (in cooperation with Dr. Gruntfest)

It was also agreed that assistance in Process Control (Part V—assigned to Dr. Weidner) will be solicitated from men active in the production of wet strength paper on the machine. Everyone was urged to push the rough draft of this monograph as rapidly as possible.

J. B. Davidson was welcomed as a new member of the West Strength Committee, and an invitation was extended, through Mr. Galloway, to the du Pont Co. to have a member of this organization join the committee.

Mr. Kane, a guest at this meeting, mentioned that his company was interested in a wet strength treatment for tea bags that would impart strength enough to hold metal stitches, and which would impart no off flavors.

C. S. Maxwell, *Secretary*
Wet Strength Committee
Stamford, Conn.



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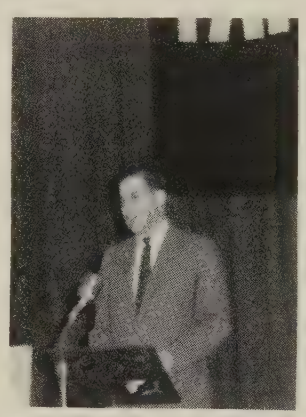
LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Chicago

A brief history of aniline printing, followed by a concise description and evaluation of its uses in package printing and its entry into the folding carton field, were main features of a talk presented at the February 11 meeting of the Chicago TAPPI by Frank A. Dick, Assistant to the Executive Vice-President, Interchemical Corp., Printing Ink Div. (IPI), Chicago.

Aniline printing is today a misnomer, since aniline dyes are no longer used in making the inks employed in this quick-drying, rotary rubber-plate process. The process originated in 1890 in England, when a Mr. Holweg, a bag machine inventor, discovered that he could make a quick-drying, fast-flowing printing ink from aniline dyes by dissolving them in alcohol and that the resulting product did not attack rubber press rollers and plates. He built and patented a combination rotary printing press and bag machine, Mr. Dick said.



Frank A. Dick, Interchemical Corp.

An aniline printing press consists basically of an ink fountain, fountain roller, transfer roller (usually etched with 140 to 210 lines per inch for more positive control of ink distribution), plate cylinder, and impression roller, Mr. Dick explained.

Sizes of aniline presses now in use, according to Mr. Dick, vary from 1-inch-wide tape-printing devices to a press that prints a 130-inch web. As an indication of practical printing speeds attainable on an aniline press, he remarked that one 118-inch aniline press now in use runs at speeds up to 1600 feet per minute.

Because plate cylinders may be quickly changed and the fountain, fountain roller, and transfer roller assembly of most aniline presses may be moved forward or back to accommodate smaller or larger plate cylinders, aniline printing lends itself to speedy, economical changes in cut-off lengths of the web.

When running porous stock, aniline needs no special drying equipment, even at high speeds. Plastic film and other hard-surface stocks often require driers, such as forced hot air, superheated steam, or infrared.

In addition to presses now being manufactured for printing carton board or for general printing of paper, Mr. Dick cited an aniline printing device which may be built into a roller conveyor so that filled corrugated shipping containers may be printed on 4 or 5 sides in the container-user's plant. One company claimed that it had reduced its container inventory to one sixth of the quantity of printed containers formerly kept on hand. Only relatively simple printing is handled by the process to date, however.

Mr. Dick said that the advent of Buna-N synthetic rubber has greatly increased the number of solvents which may be used in aniline printing. (Alcohol still is the principal solvent, although regular pigments used in oil inks have replaced aniline dyes in aniline-type inks.)

Aniline plate making has become a fine art in the past 5 years, Mr. Dick explained. He said that properly prepared plates, affixed to the plate cylinder, can be so completely made-ready that only the slightest adjustments are necessary when put on the press. Furthermore, practically any of these adjustments can be made while the press is running.

One new plate-making idea mentioned by Mr. Dick involves the use of a wire screen in the base of the plate to control shrinkage, usually a problem in aniline plate-making.

Composition of 80% of modern "aniline" ink is pigment, ethyl-alcohol solvent, and a suitable resin. Water-base inks are used for some types of printing but in general do not produce the best quality work. Drying action of solvent-type aniline inks is the same as that of women's nail polish or any other lacquer—by evaporation. Oil-base inks dry like house paint—by oxidation.

Pointing out that the original installation cost of an aniline-printing, in-line-die-cutting-carton-combination is only about one third to one half that of the necessary sheet-fed letterpress equipment, Mr. Dick also stated that an aniline press crew may be trained in much less time than required for letterpressmen. He remarked that changing printing plates or forms is markedly faster on an aniline press than on a letterpress.

Among the special qualities of aniline inks described by Mr. Dick are that they are virtually odorless upon drying and they dry so fast that the offset problem is entirely eliminated in all but a few instances.

At present, the handicaps of the aniline process are those of the rubber printing plate. In general, present screen work on aniline is done with 65 or 80 lines per inch.

Press runs of 1,000,000 impressions from one set of plates are normal for aniline, with some running to 6,000,000 on nonabrasive stock.

EDITOR'S NOTE: Aniline printing, which has attained such popularity in printing glassines and plastic films for candy and food wraps and bags that the "aniline-type" ink business of a leading manufacturer has increased 3000% since 1940, and now has its foot inside the door of the folding paper box industry.

Although aniline still cannot be employed to produce the wide variety of work done by other processes, particularly where fine screens are involved, the number of different products packaged in aniline-printed cartons has been growing steadily for the past 6 or 8 years.

Chicago Section meeting held Feb. 11, 1952

A disadvantage of aniline printing of folding cartons is that there "is no real chance of obtaining a semi or full gloss with present inks," Mr. Dick said. He pointed out, however, the ease with which a full gloss is obtained with a coat of varnish, which, in the aniline process, is applied in the same operation as is the printing, at a definitely lower cost than letterpress or other varnishing methods.

The group at the February meeting of the Chicago Section

One of the special advantages of aniline printing is that the final result can be seen almost immediately after the impression is made by the press since there is virtually no waiting for ink to dry or set, as is the case when printing with oil inks.

The same colors, shades, and hues obtainable in oil printing inks are also available in aniline inks since pigments used for the former are also used for the latter.

The following were among the topics discussed in the question and answer period after Mr. Dick's talk:

Q.: Is print from water-base aniline inks water resistant?
A.: With present inks it is after about 2 weeks' aging. A new ink, just developed, promises to give water-resistant results almost immediately after printing.
Q.: How much is the gloss obtainable improved in printing folding cartons by using clay-coated stock?
A.: None with present aniline inks.
Q.: If "aniline" is a misnomer, what is the correct designation for the process?
A.: "Aniline," at present, since various organizations trying to develop a new name have not come up with a final suggestion.
Q.: What effect does the aniline system have on paper deinking or pulp recovery?
A.: Recovery about the same as for oil inks.
Q.: Can you get as good a rub test on aniline printing as on oil ink?
A.: Yes, in general.
Q.: Can you hold good register on an aniline press?
A.: Yes, but varies with press, stock, and type of work.
Q.: Does aniline present a fire hazard?
A.: Yes, but proper ink storage room greatly lessens it and proper ventilation at press gives excellent control of the hazard under normal atmospheric conditions.
Q.: How about toxicity problem?
A.: Usually the solvent is ethyl alcohol and is not especially toxic except in extremely heavy doses.

Warren R. Price, *Chairman, Publicity Committee*

Empire State

The annual meeting of The Empire State Section will be a joint meeting of the *Niagara Branch of the Technical Section of CPPA* and the *Empire State Section of TAPPI* on June 19 to June 21, 1952, at the *General Brock Hotel, Niagara Falls, Ontario.*

TENTATIVE PROGRAM

1. General Program

The following program, which has received favorable consideration at the general meetings of our Planning Committees, is open for such revisions as may appear desirable until the next general meeting of our Planning Committees.

Wednesday, June 18, 1952

7:30 p.m.—Registration for local people and early arrivals

Thursday, June 19, 1952

9:00 a.m.—Reception and Registration
9:30 a.m.—Panel Meeting—Waste Paper
12:30 p.m.—Luncheon—Address by an *Outstanding* Speaker
2:00 p.m.—Panel Meeting—Mechanical Pulp

Friday, June 20, 1952

9:30 a.m.—Panel Meeting—Pulp Bleaching
2:00 p.m.—Mill Visits and Golf

Saturday, June 21, 1952

9:30 a.m.—Panel Meeting—Quality Requirements by Paper Consumers
2:00 p.m.—General Entertainment
6:00 p.m.—Cocktail Hour
7:00 p.m.—Dinner—Address by an *Outstanding* Speaker
9:00 p.m.—Special Entertainment and Dance

2. Technical Program

(a) Addresses at the Opening Luncheon and the Closing Dinner. The speakers for these general sessions will be outstanding leaders in the pulp and paper industry.

(b) Panel Meetings. Panel Schedules: The following schedule for the four panel meetings is suggested—Opening Remarks by the Panel Moderator; Presentation of Papers by Panel Members; Discussion Period; Summation by the Panel Moderator.

Panel Moderators: The four men who will serve as moderators for the four panels have a broad commercial background in the respective fields. They are close to recent developments and have demonstrated a high degree of competence in handling a group meeting.

Panel Members: These men are specially qualified by a wide, firsthand experience to present the picture on latest developments in their respective fields.

First Panel Meeting

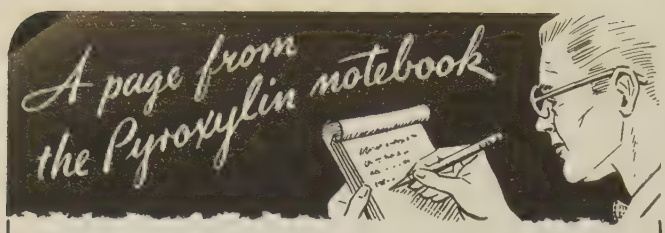
Time—9:30 a.m., Thursday, June 19, 1952.
Subject—"Waste Paper—Its Growing Importance to the Paper Industry."
Moderator—H. P. Bailey, International Paper Co.
Papers—(1) Statistics on the increased utilization of waste papers in the U. S. and Canada over the past 20 years—Earle Weaver, International Paper Co.
(2) Collecting, grading, and sorting of waste papers—Haskell Stovroff, Buffalo Waste Paper Co., Inc.
(3) Nonfibrous materials present in waste papers and their reactions with caustic soda; elimination of tacky spots in papers produced from the recovered stock—D. D. Uong, Fitchburg Paper Co.
(4) Processes for the recovery of ledger stock and other waste papers essentially free from groundwood; use of the recovered stock in paper manufacture—R. W. Hynes, Newton Falls Paper Mill, Inc.
(5) Processes for the recovery of magazine stock and other waste papers with a significant groundwood content; use of the recovered stock in board and paper manufacture.
(6) Handling of high wet-strength papers in the waste paper recovery process—S. G. Stapley, Provincial Paper, Ltd.
(7) Recovery of heat and chemicals in waste paper mills—F. C. Goodwill, St. Regis Paper Co.

Second Panel Meeting

Time—2:00 p.m., Thursday, June 19, 1952.
Subject—"Mechanical Pulp—Its Expanding Applications in Paper Manufacture."
Moderator—Lyman Beeman, Finch, Pruyn & Co., Inc.
Papers—(1) Statistics on the production and applications of groundwood over the past 20 years.
(2) Recent improvements in the production of groundwood for newsprint and board manufacture.
(3) Trends in the use of groundwood for the production of magazine, book, catalog, directory, and allied papers.
(4) Fields for groundwood in the manufacture of napkins, tissue, towelling, and waxed papers.
(5) Status and outlook on the production and utilization of semichemical pulps and other high yield pulps.

Third Panel Meeting

Time—9:30 a.m., Friday, June 20, 1952.
Subject—"Recent Trends in Pulp Bleaching Processes."
Moderator—To be selected.



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(A) HEAT SEALS ON GLASSINE,—Proxmelt No. 22 has been developed,—gives seals retaining high strength on glassine at low humidity. Seal does not deteriorate during distribution and merchandising (uses,—heat sealing bags, end seals, stickers, bands, etc.)

(B-1) PROXGLAZE 35-165,—NOW IN COLORS. Pyroxylin's clear high lustre paper coating varnish is now available in many pigmented colors. Still dries and cures in ten seconds at 300°F.

(B-2) PROXGLAZE 35-165,—FOR HIGH TEMPERATURE PACKING. Catalyst is added to this paper varnish at the time of application,—gives a finish which does not become tacky up to 250°F. (salt, scrapple, prunes, glucose, etc.)

(C) MOISTUREPROOF HEAT SEALING LACQUER 35-66,—for glassine, supered sulphite, parchment, etc. This new lacquer has improved thermal behavior,—stronger and lower sealing temperature,—yet better resistance to blocking.

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PYROXYLIN PRODUCTS, Inc.
CHICAGO 32
PAOLI, PENNA. WICHITA

Papers—(1) Statistics on the production of bleached pulps over the past 20 years.
(2) Chlorine dioxide for bleaching chemical pulps.
(3) Peroxides for bleaching mechanical pulps.
(4) Peroxides for bleaching chemical pulps.
(5) Hydrosulphites and sulphur dioxide for pulp bleaching.
(6) Bleaching of semichemical pulps.
(7) Availability of bleaching chemicals.

FOURTH PANEL MEETING

Time—9:30 a.m., Saturday, June 21, 1952.
Subject—"Quality Requirements by Paper Consumers.'
Moderator—R. J. O'Brien, Moore Business Forms.
Papers—(1) Newsprint, magazine, book, catalog, and directory papers.
(2) Board and container papers.
(3) Bond and writing papers.
(4) Food packaging papers.

3. CONVENTION OFFICERS

Chairman	J. S. Reichert
Co-Chairmen	S. G. Stapley and I. V. Earle
Secretary	W. A. Logan
Co-Secretary	F. P. Heil
Treasurer	Gordon Storin
Co-Treasurer	P. F. J. Dolan

The Convention Chairman and Co-Chairmen will be *ex-officio* members of all committees.

4. OPERATING COMMITTEES

Finance Committee: Chairman, Gordon Storin; Co-Chairman, P. F. J. Dolan.
Technical Program Committee: Chairman, R. C. Shearer; Co-Chairman, W. H. Monsson.
Committee on Hotel Arrangements: Chairman, A. B. Gorham.
Reception Committee: Chairman, Gordon Storin.
Registration Committee: Chairman, Gordon Storin.
Publicity Committee: Chairman, J. J. Forsythe; Co-Chairman, W. E. Dyke.
Committee on Mill Visits: Chairman, H. E. Karberg; Co-Chairman, J. W. Youngchild.
Committee on Exhibits: Chairman, Bruce B. Gralow.
Entertainment Committee: Chairman, Don Hart.
Committee on Golf: Chairman, A. D. Hamilton.
Committee on Prizes: Chairman, B. J. Staneslow.

J. S. REICHERT, *Chairman, Empire State Section*

Kalamazoo Valley

The Kalamazoo Valley Section met at the Columbia Hotel, Kalamazoo, Mich., at 6:30 p.m. Thursday, Feb. 7, 1950. About 60 individuals were present. John R. Dam of the Allied Paper Mills, Kalamazoo, presided as chairman.

The speaker was G. G. Halvorsen, Chemical Engineer of the Dicalite Division, Great Lakes Carbon Corp., who presented a paper on "Paper Mill Effluent Control Using Filtration Coated with Diatomaceous Filteraids."

Mr. Halvorsen's talk follows:

Paper Mill Effluent Control Using Filtration with Diatomaceous Filteraids

G. G. Halvorsen

FIVE years ago, I had the pleasure of presenting a paper at the Annual Meeting of TAPPI on our laboratory and pilot plant studies on filtration of paper mill effluents using diatomaceous filteraids. These studies pointed the way to a white water filtration and recovery system which would collect 100% of all suspended solids and offer some or all of the following advantages: (1) close up the mill system, (2) use only enough fresh water to replace evaporation losses, (3) decrease furnish costs, (4) simplify and control slime and odor problems, (5) increase production, (6) increase felt life, (7) save heat and power, (8) eliminate stream pollution, and

G. G. HALVORSEN, Chemical Engineer, Dicalite Division, Great Lakes Carbon Corp., Los Angeles, Calif.

Fig. 1

(9) pay for the installation in a relatively short period based on the savings.

Since that time I have had the gratifying experience of seeing the results of these studies and our predictions culminate into reality in several paperboard mills, a tissue mill, and a roofing felt mill. The degree to which filtration is practiced and the approach to handling these waters has been somewhat varied depending upon the individual mill's situation.

To begin with . . . What are diatomaceous filteraids and why are they used in filtration operations? These filteraids are manufactured from diatomaceous earth which is a hydrated amorphous silica. Other names which have been given this material are diatomite, infusorial earth, and Keiselguhr. An inherent characteristic of this material is the structure of the particles pattern on the formation of the original tiny plants diatomaceae or diatoms, related to the algae. The very light weight of this material, high porosity, and chemical inertness are the basic reasons why it is processed into various grades of filteraids, paper aids, inert extenders, and fillers for many industries. While scientists have classified some 15,000 different species of diatoms, the types which are predominantly spicular or elongated are of most value for filteraid manufacture. The spicular type of diatoms are shown in Fig. 1.

Filtration is the separation of solids from a liquid and is effected by passing the liquid through a porous medium. The solids are retained upon the surface of the medium in the form of a cake. The rate of flow, when the solids to be removed are incompressible, is directly proportional to the filter area and pressure and inversely to the liquid viscosity. When the solids to be removed are soft or gelatinous and are compressible, the rate is independent of the pressure. Some liquids

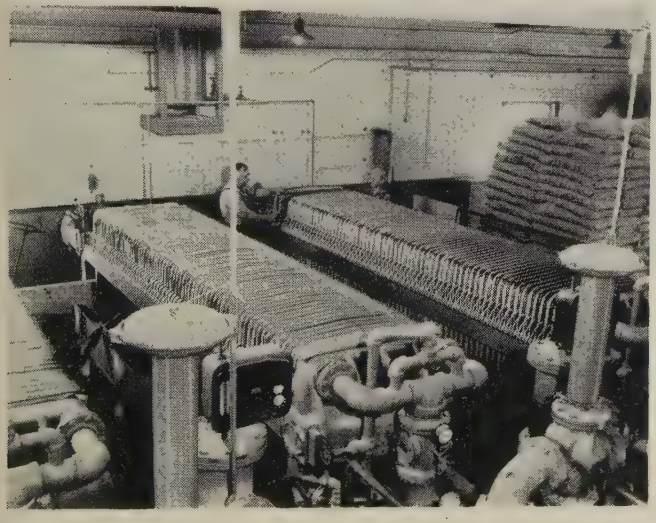
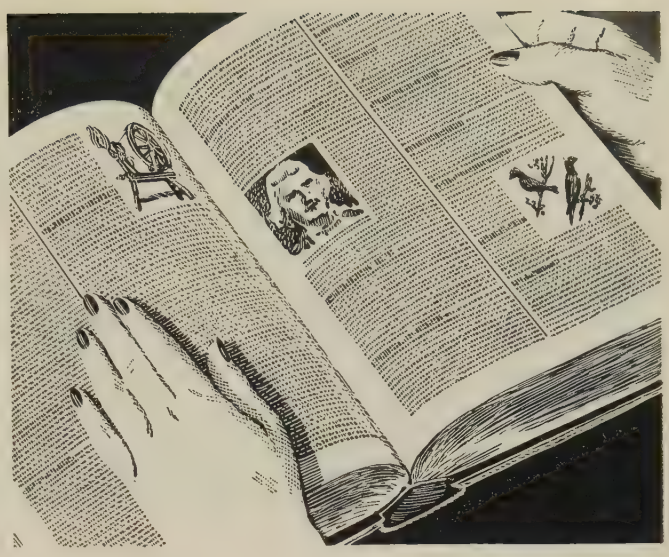


Fig. 2



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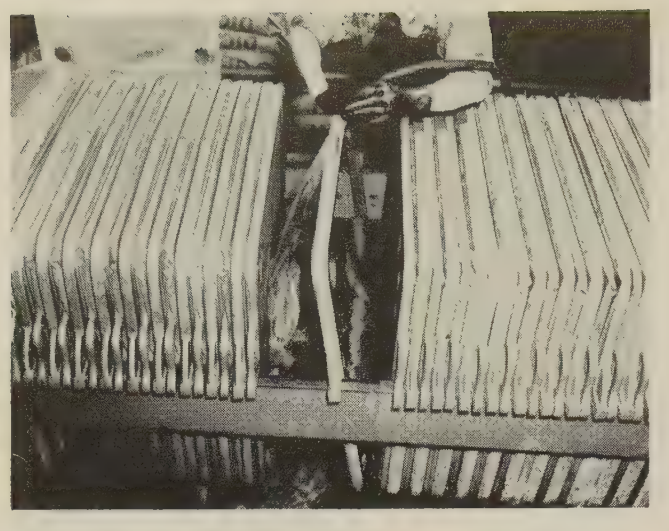

Fig. 3

containing slimy solids will have their filtration rates increased slightly by pressure or they may have a critical pressure above which a further increase results in a decreased flow rate. Depending upon the source of white water, the type of mill, and grades of paper or board being produced, the character of the suspended solids runs the gamut, therefore, it is necessary to use a material to add rigidity and porosity to the filter cake as it is formed so that it is substantially incompressible. The material that is added is called a filter aid. By far the most widely used and most efficient filteraids are those produced from diatomaceous earth. Due to the large surface area and extremely small pores formed by the lattice work of the individual diatom particles, all of the solids, even bacteria, are held back or retained in the filter cake.

The type of filtration equipment which has proved, to date, to be most satisfactory for white water filtration, is the plate and frame filter generally called a filter press. Figure 2 shows three plate and frame filters. Each filter has 1000 square feet of filtering area and a filter cake capacity of 58 cubic feet, or about 1300 pounds of filteraid and solids. A cotton duck filter cloth or old paper machine felt is placed over each plate and the filter cake is formed in each frame. Figure 3 shows a frame being emptied and the cake washed down. This cake, together with the filter paper, is returned to the filler furnish in board mill operation. The filter papers can be seen which are placed over the cloth. These are used to eliminate precoating with filteraid, to keep the cloths clean and also to make it easier to dump the filter. These filter papers can be most any type of paper which is reasonably porous and at least strong enough to handle when assembling the filter. No great strength is necessary as they are supported by the filter cloth. A sheet of 9-point semichemical is being used in one board mill. They have also used 9-point straw or kraft with equal success. Other mills have used 32-pound saturating felt, 48-pound indented, or 9-point bleached sulphite.

A filter cycle length is usually limited by the cake space or frame thickness. General practice in white water filtration is to use frames $1^1/_2$ inches thick. The quantity of filteraid added and the amount of suspended solids in the water will, of course, determine how long the filter cycle will be before clean-up. In cases where insufficient filteraid is used, the flow may drop off before reaching a full cake, due to compressibility, and the filter would have to be cleaned.

There are economies that a filtration system can effect in addition to solving some of the more pressing problems confronting many mills such as diminishing fresh water supplies and pollution restrictions being imposed. Clean warm water is available for felt cleaning, made entirely free of slime and

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bacteria by filtration and chlorination. A board mill producing folding cartons, container liners, and specialty board, which has had an opportunity to evaluate some of these factors over a period of time, reports an increase of 300 to 500 tons per felt or about 10 to 15% increased felt life. In no instance has machine speed been reduced because of a dirty felt. This filtered water can be used for practically any application for which fresh water is used. Since using filtered white water in place of fresh water, this same mill reported a saving of 30¢ per ton of board due to the use of clean, filtered water being used. To maintain their normal brightness standard they could use more lower brightness furnish. Low volume high pressure showers can operate with filtered white water affording reduced pumping costs or reduction of fresh water usage or both depending upon the mill's present water system.

Figure 4 shows filtered white water being used on the bottom felt of a seven cylinder 132-inch board machine producing 120 tons per day. Here, two oscillating low volume high pressure showers are used with one conventional high volume shower, all operating on filtered white water.

Figure 5 shows a typical white water before and after filtration. The water is of crystal clarity completely free of suspended solids, bacteria, and slime. The comment which is frequently expressed when paper men first observe the filtered white water is, "That's better than our fresh water."

White water filtration, using diatomaceous filteraids, affords a 100% positive removal of suspended solids. Changes which would normally upset clarification in a settling or floatation system such as furnish changes, chemical treatment, shutdowns, start-ups, etc., will not affect the quality of the filtered water; it will always be 100% free of suspended solids. The filtration cycle length may or may not be changed by such variables.

Figure 6 shows a three 1000-square feet filter installation

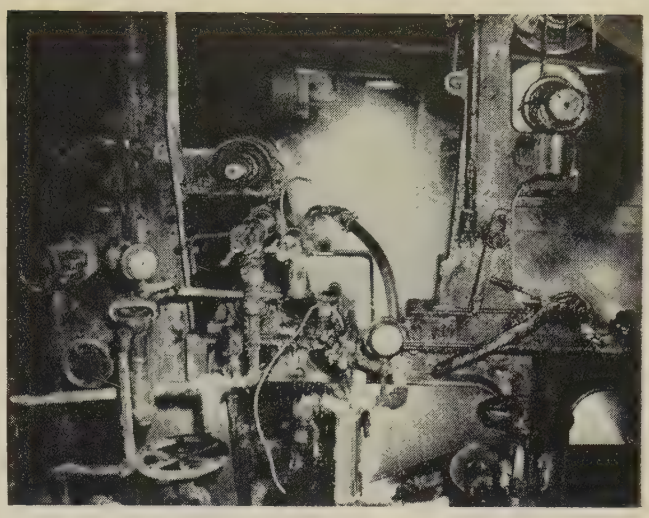
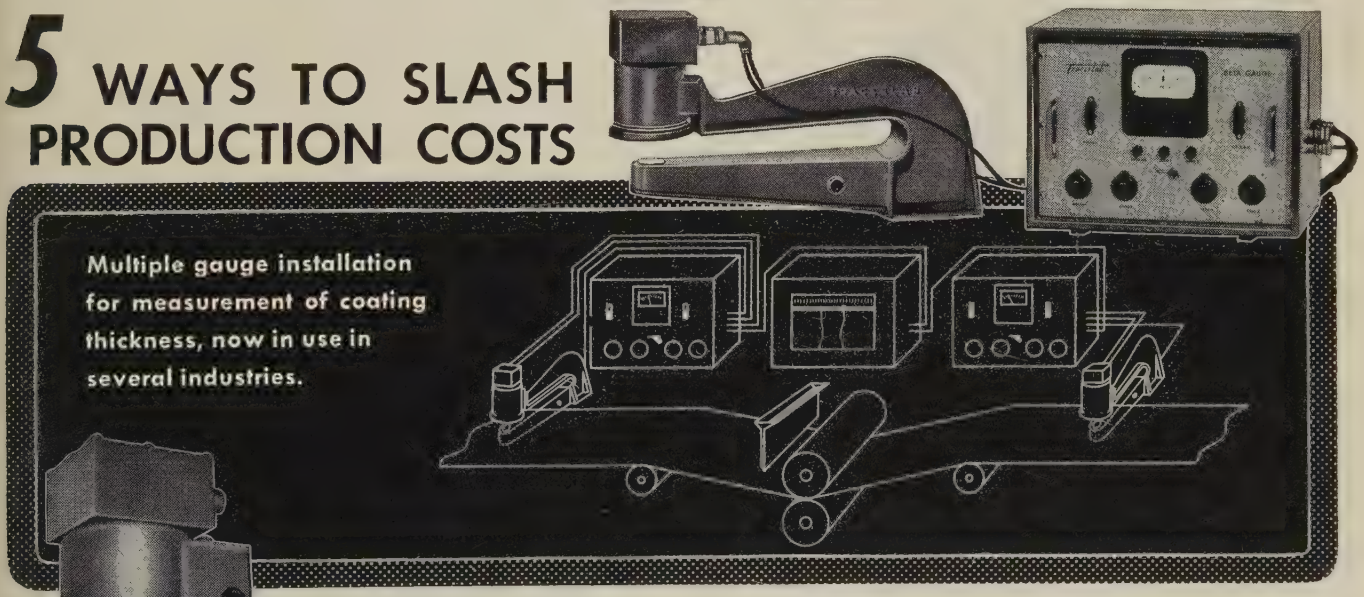


Fig. 4

in a mill producing facial tissue. The filters are installed, in this instance, after a floatation clarifier which this mill had been previously operating. This is a relatively new installation; however, on their first month's operation, their fresh water requirements were reduced from 2100 to 250 g.p.m. and effluent from 2100 to 200 g.p.m. Their shrinkage, which normally runs between 11 to 13% was reduced to 6.4%. The headbox temperature which is normally about 61°F., increased to 83°F. This installation is similar to those already installed in other mills. Automatic flow controls for each filter can be seen in the foreground. Each filter can be set for any rate of flow desired and a constant rate of flow can be maintained which is desirable to obtain maximum filtration efficiency. The filtered effluent for each filter can be

5 WAYS TO SLASH PRODUCTION COSTS



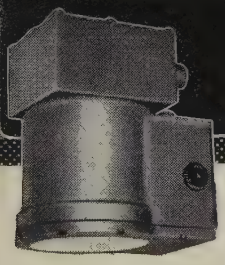


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Fig. 5

readily observed at the sight glass in the discharge manifold.

The filteraid feeders shown in Fig. 7, which are of the vibrating type, are set to feed the amount of filteraid required. Once they are set, little attention is required other than to keep the hoppers full. Each hopper has about 300 pounds filteraid capacity. The filteraid is fed continuously into a stand-pipe on the suction side of the pumps which are shown in Fig. 8. The pumps are rated at 400 g.p.m. each at 175-foot head. The piping and valve arrangement is such that any pump can be used on any filter.

Figure 9 shows an installation in a two-machine board mill producing 280 tons per day of folding and set-up boxboard. The effluent being filtered is low solids water from the machines averaging between 2 to 3 pounds solids per 1000 gallons. No settling, floatation system, or mechanical saveall is used. At the start-up, filter cycles of 10 to 12 hours at a rate of 400 g.p.m. per 1000-square foot filter were obtained and filteraid consumption averaged 2.2 pounds per 1000 gallons filtered. A comprehensive evaluation is as yet not available due to the short time this installation has been running. The latest information we have is that they are now operating with less than 2.0 pounds of filteraid per 1000 gallons and the filter cycle lengths have been increased to about 24 hours at a rate of 275 g.p.m. per filter. About 50% of the increase in cycle length is due to the decreased rate of flow. The remaining increase in filterability can be attributed to easier filtering solids due to the reduction in bacteria and slime which followed after filtering for a period of time.

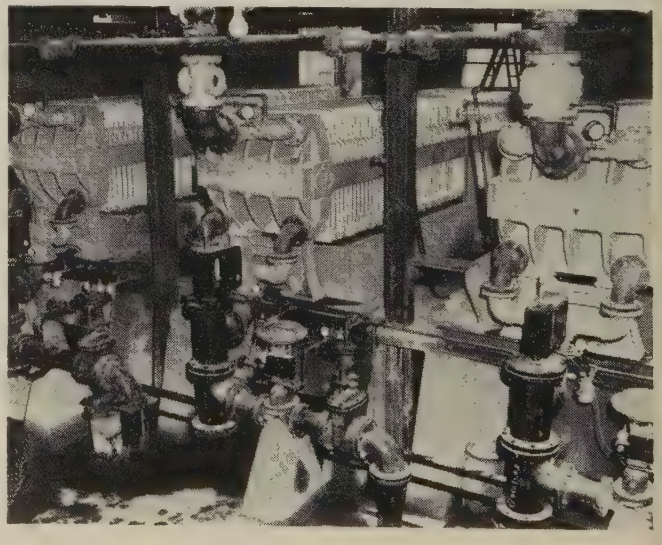

Fig. 6

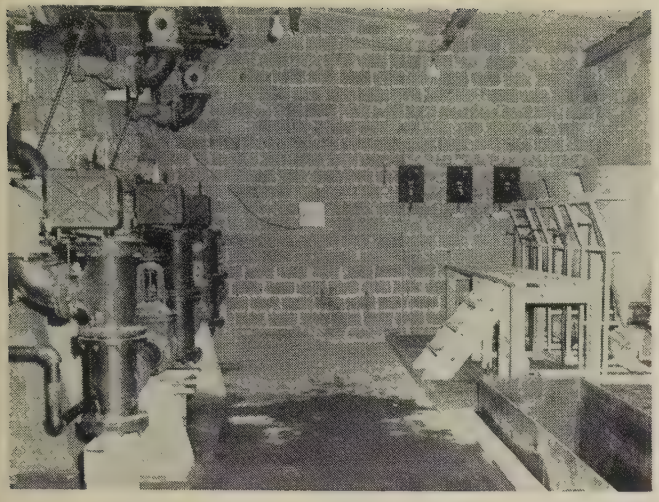

Fig. 7

On this filtration installation a surge tank or reservoir of about 15,000 gallons capacity is installed ahead of the filters, and storage of about 30,000 gallons is provided for filtered water.

We have learned through many hundreds of spot laboratory filtration tests in board mills at various sources of white waters, that the most easily filtered waters are those coming from the felt showers, presses, extractors, and vacuum pumps. These waters are generally termed low solid waters and they are usually much lower in bacteria and slimes. As I have previously mentioned, the compressibility of the filter cake or the character of the solids to be removed has more effect upon the filterability of the water than the amount of total solids in suspension. We have an excellent comparison of this at two different board mills both making about the same type of boards. Mill A is filtering their low solid waters from two machines which average about 2.8 pounds suspended solids per 1000 gallons at a rate of 275 g.p.m. on a 1000-square foot filter. They use an average of 2.0 pounds of filteraid per 1000 gallons and cycle lengths run consistent between 20 to 24 hours. Mill B, having four machines, started out by filtering water for two machines from their coagulating and settling system which collected the general effluent of the mill and reduced the suspended solids from 5 to 10 pounds per 1000 gallons to 0.25 to 0.5 pound per 1000 gallons. This water is being filtered on similar 1000-square foot filters at 265 g.p.m. per filter using 3.5 to 4.0 pounds of filteraid per 1000 gallons and averaging, over a period of one year, 15-hour cycles which may fluctuate be-

Fig. 8

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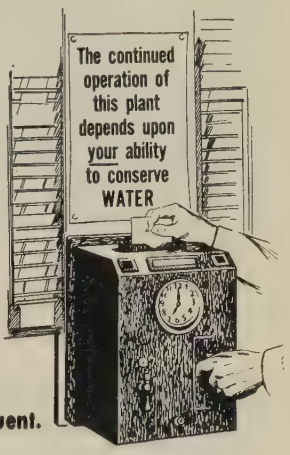
- Board
- Straw



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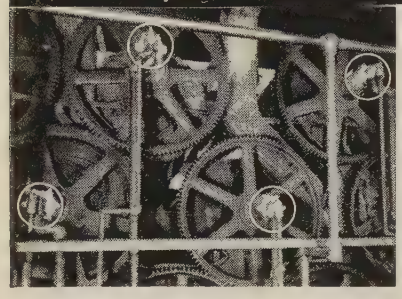

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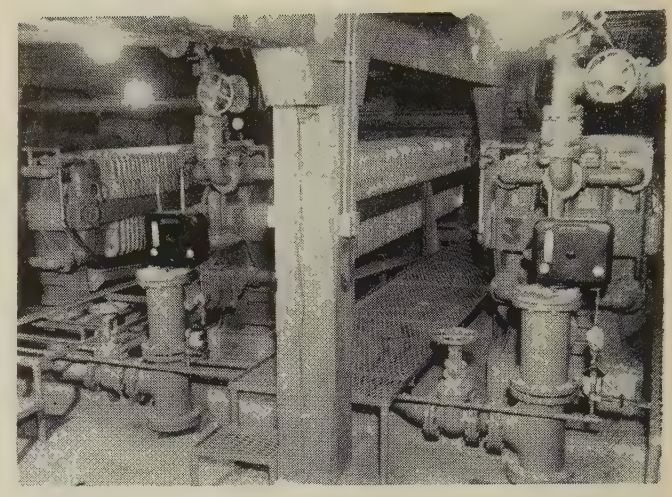


Fig. 9

tween 8 to 30 hours. In other words, for all practical purposes, we have about an equal comparison here on the type of paperboard being produced and also filtration at about the same rate of flow with the same grade of filteraid. In mill A there is a ratio of filteraid to suspended solids being filtered out of 0.7 pound filteraid to 1.0 pound suspended solids and in mill B the ratio is about 10 pounds filteraid to 1.0 pound suspended solids. In this comparison, mill A has substantially a "sterile" water system where the slime and bacteria in the water, before filtration, have been essentially eliminated. In mill B the quantity of suspended solids has been substantially reduced but the bacteria and slime still remain in the water before filtration. Mill B is presently completing the filtration system to handle their four machines, filtering low solid waters and eliminating their settling system.

In the treatment of any effluent problem, we all know that it is desirable and economical to reduce to a minimum the quantity of water to be handled.

The separation of process and nonprocess waters is, of course, one of the first steps that can be made in a paper mill in reducing the volume of effluent water to be handled. A further possibility is to separate low solids and high solids process or machine waters such as is shown in Fig. 10 for a paperboard machine. The low solid waters are separated and collected in the machine pit and a reservoir if necessary. The discharge from cylinder molds can be separated according to the machine and stock preparation system and returned to the individual stock preparation point. Surge storage is provided for the high solid waters which are returned to the filler portion of the board together with the filter cake containing the filteraid and solids from the low solid water. Mills which are operating in this manner keep the high solid system somewhat starved. If the occasion arises, low solid waters can be bled into the high solid system.

J. Howard Wright, of the S. Austin Bicking Co., reported on their filtration system at the American Pulp & Paper Mill Superintendents' meeting on Sept. 28, 1951, at Mt. Pocono, Pa. Their layout was originally essentially this same system using a coagulating and settling clarifier. The present system has, in addition, a filter after the clarifier. The clarifier is normally working on the low solid waters. This is a single machine mill producing 65 to 70 tons of chip or newsboard per day. They had previously segregated the high and low solids waters and eliminated nonprocess waters from their white water system. A brief summary from Mr. Wright's paper is as follows:

1. "Assuming the mean annual temperature of our fresh water to be 50° F., and using 120,000 gallons per 24 hours of shower water, which is used over and over after filtration, we save 50,000 to 60,000 pounds of steam per day. That in itself is a sizable advantage. The shower water is at 100 to 110° F. without use of induced heat."

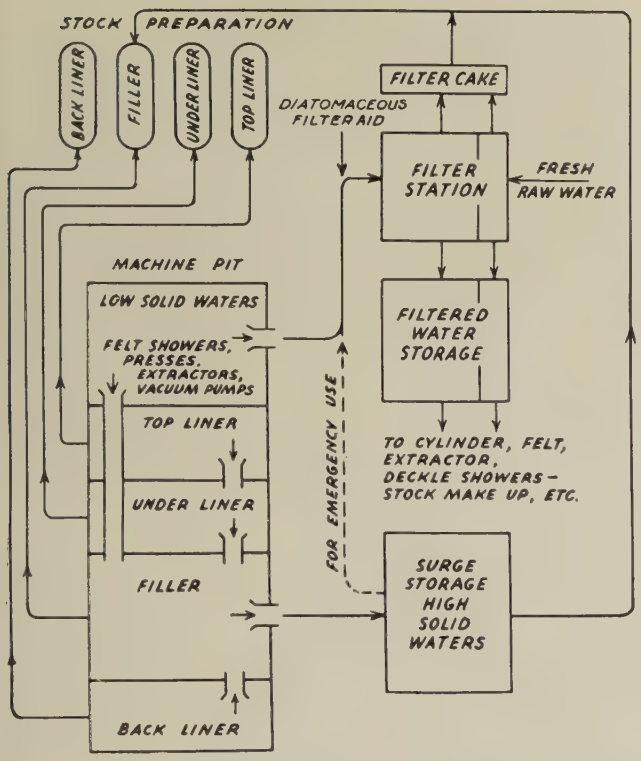


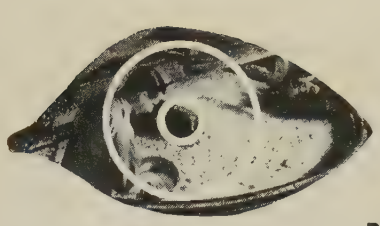
Fig. 10. Schematic flowsheet, white water filtration system, paperboard machine

2. "The filteraid, at a cost of approximately $70 per ton, is recovered 100% in the paperboard and we make a substantial profit in that direction based on present market conditions."
3. "All suspended solids are recovered."
4. "The total gallons of effluent per month averaged about 4 million gallons after a religious effort had been made to reduce the effluent. After installing the filter, this was reduced to about 20,000 gallons per month and the effluent discharged was filtered and free of suspended solids."
5. "This system provides a continuous supply of crystal clear warm water for felts, thus assuring maximum openness and efficient water removal."
6. "There were, of course, some difficulties which were originally encountered in the closing up of this mill system. One was the corrosion and erosion problem experienced on the filter pump. A cast-iron centrifugal pump had about a 3-month life." (At the time of Mr. Wright's paper, they had just installed an aluminum bronze pump. To comment further on this, the pump has now run over 8 months and is still in excellent condition. This corrosion problem was due to the high acidity which developed due to the use of alum at the settling clarifier.)
7. "The amount of alum used in the primary settling system was cut in half from about 12 tons per month to 6 tons per month."

At the end of 6 months' operation, an odor condition developed in the finished board. Chlorination had been practiced by injecting into the suction of the booster pump for the filtered felt shower water. The stock preparation temperatures were in the neighborhood of 160 to 170°F. and this temperature was not high enough to prevent bacteria growth.

Chlorine was injected at the cylinder fan pumps and the odor problem has been eliminated.

A paper on the filtration setup at Ohio Boxboard was given at the Technical Section, Canadian Pulp & Paper Association, June, 1950, Quebec, Canada. George C. Ehemman, Plant Engineer; L. K. Burnett, Quality Control Manager; and John C. Waddell, Development Chemist, presented this paper. Briefly, their conclusions are that filtrations of low solids water with a plate and frame-type filter and a filteraid, with selective return of high solids water, offers a practical solution to the recovery of process water; a means of conserving water, fibers, fillers, and heat now wasted; and also a method of decreasing stream pollution caused by paper mill effluent.



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They reported the following data:

1. "Temperature of the filtered water averaged 30°F. higher than the fresh water supply."
2. "A saving of approximately 30¢ per ton of board has been realized by furnish changes made possible by increases in brightness of the board when using filtered water in place of fresh water."
3. "Felt life increased 10 to 15%."
4. "No loss in machine speed due to dirty felts."
5. "A residual of 0.3 p.p.m. of chlorine is maintained in the filtered water going to the mill. No growth of slime has been evident in the filtered water."
6. "The concentration of the bacteria in the cake of recovered fiber and filler offers a convenient and economical place to sterilize the stock to be returned to the system, either by chemical or heat treatment. The presence of diatoms in the cake frees the stock so that it does not cause the drainage problems sometimes associated with recovered stock."
7. "Microbiological analysis has shown an average removal by the filter of 85 to 90% of the slime and odor-forming bacteria in the white water. The bacteria, so removed, are concentrated in the filter cake and are, therefore, subject to economical control."
8. "White water filtered with a filteraid is entirely satisfactory for low volume high pressure showers."

There are other applications for filteraids in paper mills and I will comment briefly on some of these applications. The advantages of using water that is completely "polished" and of sparkling clarity is becoming of more importance and is showing definite improvements in quality of finished product or in operation in many industrial uses. An excellent paper on "The Filtration of Boiler Feed Water Using Diatomaceous Earth," was given by Thomas H. Norris, mill chemist of the Iroquois Falls Division of Abitibi Power & Paper Co., Ltd., at the Annual Meeting of the Technical Section of the Canadian Pulp & Paper Association, Montreal, Que., Jan. 23, 1952.

This paper covers in detail the installation at this mill for filtering oil contaminated condensate and also boiler make-up water. Each is a separate filtration operation.

The re-use of steam condensate containing oil has become an increasing problem due to higher steam pressures and superheating. The oil becomes emulsified with the steam and forms a stable emulsion upon condensation. This emulsion has not been satisfactorily handled by the older methods of using baffle plates, coke, sponges, sand filters, or other separation media. Our experience on many marine installations and power plants, where reciprocating engines are used and oil-contaminated condensate results, indicates that oil removal can be effected by filtration with a specially treated filteraid down to 0.1 p.p.m. on condensates containing no more than 80 p.p.m. of oil. Where the oil content is higher, other grades of filteraid are employed in conjunction with chemical treatment. Filter cycles are long, ranging from a minimum of two days to a maximum of 10 days depending upon the amount of oil and other impurities in the condensate. Rates of 1 to 1.5 gallons per square foot of filter area per minute are obtained and the filteraid slurry feed ranges from one to two parts per part of oil to be removed. No other treatment is required and filtrate goes directly to the boilers or preheaters.

The installation at the Iroquois Falls Paper Mill has three filters on condensate each having 360 square feet of filter area. Their condensate averages 23.9 p.p.m. of oil and the filtrate consistently contains less than 1 p.p.m. They are removing about 65 pints of oil per day and filter at a rate of $1^1/_2$ gallons per square foot per minute with cycle lengths of 1 week. Their cost is about three-quarters of a cent per thousand gallons.

Many industries, muncipalities, and even swimming pools are filtering waters with diatomaceous filteraids. Our armed services are also using this method of clarifying water in the field. The extremely "sharp" filtering action characteristic of diatomaceous filteraids removes not only sand and dirt but also bacteria, causing various tropical diseases, such as the cysts of amoebic dysentery and the blood flukes prevalent in Philippine waters.

It may be of interest to know that there are, at the present time, five muncipalities along the Saginaw pipe line here in Michigan that are filtering their water from this line using diatomaceous filteraid filters. These filters operate at about 2 to $2^1/_2$ gallons per square foot per minute and insure these muncipalities of turbid free water at all times.

The filter equipment for industrial and municipal installations is compact and the total capital investment is low. A comparison of operating costs of diatomaceous filteraid filtration to conventional water treatment by chemical treat- and sand filtration will show wide differences depending upon the particular situation. Mr. Norris of the Iroquois Falls Division of Abitibi Power & Paper Co. reports the operating cost of their diatomaceous filters, 3 to 4¢ per 1000 gallons filtered, to compare favorably to conventional coagulation type filters. They are filtering river water for boiler make-up. The raw water has from 20 to 50 p.p.m. turbidity, depending on the season, and rate of filtration ranges from 0.25 to 0.5 gallon per square foot per minute.

RECENT BOOKS

Pulp and Paper Chemistry and Chemical Technology. Vol. I. By James P. Casey, A. E. Staley Mfg. Co. Interscience Publishers, Inc., New York, 1952. Cloth, 6 × 9, 795 pages. $15.

Mr. Casey's book on pulp and paper has been awaited with interest for a year or more. From time to time this

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reviewer has received comments from individuals who have reviewed separate chapters, all of whom advised that these particular chapters were good. Since the book has been issued, favorable comments have been received from some who have read the first volume.

Mr. Casey is, at present, Director of Technical Service for A. E. Staley Mfg. Co., Decatur, Ill., and was formerly Associate Professor of Pulp and Paper Manufacture at the College of Forestry, State University of New York. Mr. Casey once said that the best way to learn the details about an industry is to write a book about them. Knowing that his readers would be critical he made sure that their causes for criticism would be kept at a minimum.

This book has been written for the chemist who has more than a casual interest in the paper industry. It combines the features of an advanced textbook and a reference book. The material is presented in fundamental terms, but has tried to bridge the gap between theory and practice. It is presented from the viewpoint of a colloid and physical chemist.

Volume I is devoted to pulping and papermaking. Volume II, which is scheduled for publication in May, 1952, will deal with converting practices. Volume I covers the following subjects: Cellulose and Hemicellulose, Lignin, Pulpwood, Pulping, Bleaching, Fiber Preparation, Nature of Fiber Bonding, Sheet Formation, Filling and Loading, Internal Sizing, Surface Sizing, Wet Strength Coloring, Microbiology, and Water. It contains an excellent subject and author index.

Mr. Casey is Chairman of the TAPPI Nonfibrous Materials Testing Committee. He is to be congratulated for making this effort to prepare a text that will be of great value to his fellow pulp and paper technologists.

R. G. M.

The Chemistry of Lignin. By Friedrich Emil Brauns, Institute of Paper Chemistry, Appleton, Wis. Academic Press, New York, 1952. Cloth, 6 × 9, 808 pages. $14.50.

This is a welcome addition to the libraries of pulp and paper research men. Many people who have been acquainted with the work of Dr. Brauns have wondered when he would prepare a book on the subject. Knowing the scientific character of the author and appreciating that his Teutonic thoroughness would lead to endless postponement of such a text until the difficult lignin problem was solved it is a pleasant surprise to have him reveal the state of the knowledge of lignin at this time. As he states in the preface, work on this book was started 20 years ago and was intended solely for the author's personal use. His decision to release so much valuable information is based on the intensified interest on the part of chemists, botanists, and others and the great need for the information that has been accumulated in recent years.

The study of lignin is difficult and there are but few chemists that wish to undertake a scientific study of the material. It is the hope of the author that the present volume will reduce much of this reticence and lead qualified scientists to enter into this important field of study, a study that may some day have as prolific consequences as the original study of coal tar which has its origin in these same raw materials.

Among the major chapter heads of Dr. Braun's book are: Evolution of Lignin Chemistry, Definition and Description; Color Reactions of Lignified Materials; Isolation of Lignin; Determination of Lignin, Physical Properties of Lignin; Constituent Groups, Acetylation, Alkylation, Halogenation, Nitration, Sulphonation; Hydrolysis, Alcoholysis, Mercaptolysis, Phenolysis; Reduction, Hydrogenation, and Hydrogenolysis, Oxidation, Alkali Fusion; Thermal Decomposition; Biological Decomposition; Theories of Structure; Lignin Linkages; Theories of Formation; Synthetic Lignins. A voluminous author and subject index and a large number of subtopics.

Thank you, Dr. Brauns.

R. G. M.

Phillips Paper Trade Directory of the World—1952. S. C. Phillips & Co., Graham House, 3 Tudor Street, London, E.C. 4, England. Cloth, 5 × 8, 747 pages. 37/6d.

The 1952 Phillip's Directory brings up to date the names, locations, number of machines, and annual output of the pulp, paper, and board mills throughout the world. Special emphasis is given to the British mills and converting plants. In addition to the information that is expected in such a directory a glossary of trade terms in English, French, and German is given. In view of the growing interest in international trade this volume should find increasing usage in this country.

Australian Pulp and Paper Industry Technical Proceedings—1950. Vol. 4. South Melbourne, Victoria, Australia. Cloth $5^1/_2 \times 8^1/_2$, 406 pages. $8.50.

This is the fourth series of papers issued by the Australian Pulp and Paper Technical Association. It is the first to be issued in a cloth-bound printed format. Although it is a little late in being distributed this seems to be a common failing of many technical societies and is often due to the difficulty of getting authors to release their particular contributions. Fortunately, the nature of the contents is of value for years after publication.

Some of the papers deal with subjects such as: Optimum Size of Machines, Stainless Steel Linings for Digesters, Dynamic Balancing of Rolls, Bleaching Eucalypt Soda Pulp, Control of Slime, Stock Pumping Problems, Friction Loss in Copper Pipe and Wood Stave Piping, Testing of Paper, etc.

Pulpwoods of United States and Canada. 2nd Ed. By Irving H. Isenberg, Institute of Paper Chemistry, Appleton, Wis. Cloth, $8^1/_2 \times 11$, 187 pages. $5.00.

The second edition of this fine reference book is a vast improvement over the first edition. It is printed (photo-offset), not mimeographed, and bound in cloth rather than heavy paper.

Each item gives details relating to a particular species such as Eastern White Pine and contains the following details: Scientific and Common Names, including Synonyms, Range (Showing Map), Dimensions of Mature Trees, Bark, Sylvics, Features of the Wood, Microscopic Structure, Physical and Mechanical Properties, Chemical Composition, Pathology, Utilization and Supply.

As usual Dr. Isenberg has done a fine job.

Mechanical Engineers Handbook, 5th Ed. Rev. Edited by Lionel S. Marks, Gordon McKay Professor of Mechanical Engineering, Emeritus, Harvard University. McGraw-Hill Book Co., New York, 1951. Cloth, 6×9, 2236 pages. $15.

Mark's Mechanical Engineers Handbook requires no description for individuals who keep a copy within easy reach. Sufficient is it to say that the Revised Fifth Edition is ready. It is larger and more up to date than its predecessors. It follows the precedent of the Chemical Engineers Handbook in being issued in a larger format and more readable typography. In the past there has been almost a tradition among publishers of voluminous handbooks to try to approach pocket size and not have too much space between covers, thereby using as small type and as thin paper as possible. It is heartwarming to have this practice ended because if there is anyone who needs to have an easily readable text it is the person who knows how to use one of these reference books.

Paper and Paper Making. By F. H. Norris, Former Lecturer at the Borough Polytechnic, London. Oxford University Press, London, England, 1952. Cloth, 6×10, 351 pages. £1/11 /4d.

From 1945 to 1948 a series of articles by the author ran in the issues of the *World's Paper Trade Review*. The present volume uses these articles as a basis and brought up to date is now available as a bound volume. The appearance of the book is much above the average since coated paper is used, offering thereby a fine foundation for the 150 illustrations, including half-tones.

It is written for the younger men in the industry and technical schools and, of course, is based upon British mill practices.

Its chapter headings include: Treatment of Rags, Esparto, Straw, etc.; Mechanical and Chemical Wood Pulp; Breaking, Washing and Bleaching; Beating; Loading; Hand-Made Papers; Paper Machines, Watermarking; Power House; Newsprint; Water, Tub-Sizing and Air Drying; Dampening, Coated Papers; Quality and Durability of Paper; British Trade Customs.

Note: Books reviewed in this section may be obtained from the Book Department of the Technical Association of the Pulp and Paper Industry, 122 East 42nd Street, New York 17, N. Y.

EMPLOYMENT SERVICE

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P185-52. Chemical Engineer. For specialty mill in the Miami Valley. Prefer man with paper mill experience to conduct and supervise mill trials, routine and control tests. In replying state complete history and salary required.

P200-52. Chemical Engineer. For development and control work in a pulp and paper mill located in the province of Quebec. Experience desirable but not essential. Salary open. Excellent opportunities. Reply in detail.

P201-52. Chief Engineer. To take charge of approximately 25-man Design and Production Engineering Department for established East-Coast manufacturer of heavy industrial machinery. Paper handling experience desirable but not necessary. Excellent longevity record, all benefits including pension. This can be a life-time job with plenty of opportunity for advancement.

P202-52. Chemists. Packaging field experience preferred. Large well-known concern located New York City has opening for B.S. graduate with minimum of one (1) year's experience in laboratory work. Salary commensurate with experience and qualifications. 5 day week. Submit detailed résumé of experience, education, age, present salary, etc.

P203-52. Quality Control Man. Small specialty paper mill (one fourdrinier and one cylinder machine) in Northern Ohio has opening for able, alert man to head quality control department. He must be a graduate chemical engineer or chemistry major with at least 5 years' practical production experience in a paper mill,—preferably in quality control department or as an assistant superintendent. Possibilities for advancement are excellent in this large, established concern which has a number of interests.

Positions Wanted

E165-52. Graduate Pulp and Paper Mill Chemist, with long varied experience, seeks a position anywhere as a paper mill, converting plant, or associated industry technician, laboratory director, or technical-papers sales service man.

E167-52. Chemist. Chemical engineering degree with graduate work in pulp and paper. 5 years in paper conversion plant specializing in plastic and synthetic resin coatings, knowledge of adhesives, paper, waxes, and equipment. Also 3 years' organic laboratory work. Desires position in East in either research or development.

E168-52. Chemical Engineer, 30, family, Experience in semi-chemical pulping of hardwoods, multistage bleaching including the manufacture and utilization of chlorine dioxide desires position with progressive pulp mill interested in increasing pulp production by better utilization of hardwoods.

E169-52. Young chemically trained college graduate seeks position in the purchasing or sales department of firm. Four years' business experience. Résumé furnished upon request.

E170-52. Chemical Engineer. 16 years' experience in coated board, technical service work on use of starch in the paper industry, and development of all types of industrial adhesives.

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

Electrical Engineering Committee

Cable Subcommittee

The third meeting of the TAPPI Subcommittee on Cable convened in the Board Room of the Technical Association of the Pulp & Paper Industry Headquarters in New York City at 9:45 a.m., November 13, 1951, with S. J. Rosch of Anaconda Wire & Cable Co., R. B. McKinley of General Electric Co., R. C. Graham of Rome Cable Corp., E. W. Davis of Simplex Wire & Cable Co., G. W. Zink of Haversbaw Cable & Wire Div., Phelps Dodge Copper Products Corp., E. G. Sturdevant of the United States Rubber Co., M. H. McGrath of the General Cable Corp., W. C. Warr of the General Cable Corp., D. A. Silver of the General Cable Corp., John Eyton of the Abitibi Power & Paper Co., R. H. Andrews of the Canadian Wire & Cable Co., John Hogan of the Okonite Co., O. A. Smith of Merritt-Chapman & Scott Corp., and A. O. Mortenson of the St. Regis Paper Co. present.

MR. MORTENSON: Gentlemen, the hour of convening the third meeting of this TAPPI Committee and the second meeting of the Joint Committee of the Technical Association of the Pulp and Paper Industry and the Insulated Power Cable Engineers Association Joint Committee is at hand. Perhaps I should say at the outset that we do hope that we can bring the work of this Joint Committee to a close. We hope that we can complete everything we have in hand before this meeting is adjourned so we can, at the general meeting of TAPPI in February, present the specifications, and wind up the work of this committee. So we may be here more than a day. I trust that most of you have come here with the intention of staying until the job is done. However, Mr. Rosch informed me this morning that he is due in Washington tomorrow so he won't be here if the meeting goes beyond today. Hope this is not the case with anyone else in attendance here.

Has everyone a copy of the minutes of the last meeting? How many of you have gone over these minutes? I think all of you have a copy with the possible exception of our Canadian friends, Mr. Eyton and Mr. Andrews.

Are there any errors or omissions that should be taken care of?

MR. SMITH: I have one. I am on record as saying I have experienced many d.c. failures. I have not experienced any d.c. failures.

MR. MORTENSON: Where in the minutes, Smitty, can we find that statement?

MR. SMITH: Page 33, line 9, see *Tappi* 34, No. 9: page 102A, 24th line, 2nd col.(Sept., 1951).

MR. MORTENSON: I will read what Smitty is reported to have said.

"MR. SMITH: Have experienced many d.c. failures and there is need for specific recommendations for d.c. Sorry we overlooked it in our questionnaire. As the gentlemen say, wet location failures predominate on d.c. However, we have been using the same type of cable throughout on our d.c. drives as on a.c. I think Mr. Davis remarked that we should come out with a special recommendation for d.c."

Now, just how should this be changed?

MR. DAVIS: I would say omit the first and second sentences.

MR. MORTENSON: If there are no objections that correction will be made. Mr. Smith's corrected remark will then read—"As the gentlemen say, wet location failures predominate on d.c. However, we have been using the same type of cable throughout on our d.c. drives as on a.c. I think Mr. Davis remarked that we should come out with a special recommendation for d.c."

Are there any other errors to be corrected? All right, hearing none, the minutes of the last meeting are hereby approved as corrected.

I think it only fitting to let Mr. Eyton and Mr. Andrews who have given us a tremendous amount of information present it to us at this time. Would you, John? I have your material before me and I think the members of this committee also have copies and if you could make a brief presentation at this time we would appreciate it.

MR. EYTON: Mr. Chairman, we found that this TAPPI questionnaire was very, very difficult for the average mill to fill out. Some of the chaps really did not have time to fill it out. I tried filling it out and had considerable difficulty. I sent copies to four manufacturers in Canada and asked them to see what they could do with it. The Canada Wire & Cable Co. replied. However, it took them quite a while. They went into the matter rather extensively and what they recommended you have in my report. I think if all members have copies I would appreciate comments. That's all I have to say now. Perhaps Mr. Andrews has something to say.

MR. ANDREWS (addressing Mr. Eyton): I have been guided by what you gave me. I don't know how much further we can carry it, until the experience of other people can be brought forth. Experience is the thing that counts. We can say anything we like. People who use cable must be our guides in this matter.

MR. MORTENSON: The questionnaire did bring to light, notwithstanding what Mr. Eyton said a moment ago, a tremendous amount of information as to what type cables are most preferred in the industry, how failures occurred, how, where, and so on. I believe it ties in very closely with the information you have given us here.

(Mr. Mortenson refers to the typed sheets presented by Mr. Eyton and Mr. Andrews.)

Our purpose at this meeting is to write specifications that will cover all of the departments in the industry patterned from what experience has shown is best. How can we go about writing those specifications, setting this thing up so it can be adopted, presented to TAPPI for adoption? What is the best manner in which to tackle that problem?

MR. ROSCH: Mr. Mortenson, the IPCEA group has gone over the general specifications and the different methods of testing at present contained in this particular pamphlet (IPCEA Standard S-19-81) and we have been able as an industry to boil that down to a series under certain operating conditions. For instance, we have considered your industry as a chemical industry and we have written general specifications to cover. Mr. Davis has our recommendations written up and if you will allow him to read what he has you will see what we are driving at. If we can agree that what we have given you is all we need the whole problem becomes quite simple. From that point on we can write the few specifications for TAPPI very easily.

MR. DAVIS: Now you told us, Mr. Mortenson, you wanted specifications that would be common to all manu-

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facturers of wire and cable and not peculiar to any company or group of companies. Now, if you built that around what IPCEA already has it would mean that you would not have to copy it all into your specifications. Simply settle on this way of doing it and you would have your job done in a simple form. We had a meeting in Boston. We considered the results of your questionnaire and based our, the IPCEA, recommendations on those results. We will submit these recommendations as a basis for your specifications. Do you remember the replies to your questionnaire as to what went wrong with the cables? Where were most of your troubles? It was hard to put the finger on the insulation itself. On the other hand, one or two things could be picked out such as, deterioration due to age and deterioration due to moisture, oil, etc. Didn't most evidence show that many failures were due to the chemicals encountered? We have written this out.

(Mr. Davis reads his letter dated Nov. 8, 1951.)

INSULATED POWER CABLE ENGINEERS ASSOCIATION
NEW YORK

TO: JOINT COMMITTEE—TAPPI-IPCEA DATE: Nov. 8, 1951
FROM: Mr. E. W. Davis PROJECT NO.: 369

SUBJECT: Application of Electric Cable

Gentlemen:

The subcommittee of IPCEA has had two meetings with the cable engineering committee of TAPPI to consider specifications for insulated wires and cables for use in the pulp and paper industry.

On Thursday, Nov. 1, the IPCEA subcommittee met in Boston to study the data accumulated at the two meetings mentioned above and prepare recommendations to the Joint Committee. At the meeting were Messrs. Davis, Graham, Hogan, Rosch, Silver, Sturdevant, and Zink.

The subcommittee report was reviewed by the interested sections of IPCEA on Thursday, Nov. 8, with the following recommendations.

I. Assume that the chemicals and conditions encountered in a typical southern sulphate pulp and paper mill as shown in Exhibit I attached herewith are substantially the same for mills employing the other processes. (Sulphite, groundwood, rag, wastepaper, etc.)

II. (a) Eliminate the use of cotton or fabric outer braids on all cables wherever possible—substituting neoprene protective sheaths therefor.

(b) Make no distinction between synthetic and/or natural rubber when specifying rubber compound insulation.

(c) All cables for 600 v. working pressure or less—
A.C. Operation—
Conductors, all sizes:
1. Rubber insulation suitable for 75 °C. (167 °F.) operation with moisture resistance in accordance with IPCEA Standard S-19-81—Appendix N.
2. Thickness of insulation per IPCEA Standards S-19-81—Table II—Part 3.
3. Neoprene sheaths per IPCEA Standard S-19-81—thickness in accordance with paragraph 6.3.2.3 and quality in accordance with Appendix K.

(d) Alternate conductor size smaller than No. 6 Awg.—Max. Operating Temp. 60 °C. (140 °F.) Thermoplastic insulation per IPCEA Standard S-19-81—thickness in accordance with column "B" or "C" whichever is applicable to conditions of installation and quality in accordance with Appendix I.

(e) Maximum operating temperature over 75 °C. (167 °F.).
Underwriters' Type AVA or ACV for dry location.
Underwriters' Type AVL or VCL for wet location.

(f) D.C. Operation—Wet locations.
Manufacturer's recommendation.

(g) All cables for operation over 600 v. working pressure.
1. Ozone-resistant rubber insulation suitable for 75 °C. (167 °F.) operation to meet requirements of IPCEA Standard S-19-81—Section 4.4 and Appendix D, and Appendix N for moisture resistance.
2. Shielding in accordance with IPCEA Standard S-19-81—Part 5.
3. Neoprene sheath per IPCEA Standard S-19-81—thickness in accordance with paragraph 6.3.2.3. and quality in accordance with Appendix K.
4. (Alternate)—Polyethylene (manufacturer's recommendation).

Maximum operating temperature over 75 °C. (167 °F.).
AVA or ACV for dry locations.
AVL or VCL for wet locations.

E. W. Davis

Mr. Davis: We feel that will take care of every one of your conditions as we see them from your questionnaire.

(All references contained in the above letter are set forth below in their entirety for clarification.)

Exhibit I

CHEMICALS AND CONDITIONS ENCOUNTERED IN A TYPICAL SOUTHERN SULPHATE PULP AND PAPER MILL

A Chip Preparation—Outdoor conditions, lime dust, blow steam, alkaline fume from recovery stacks, water.
B Wood Room—Indoor conditions.
C Digester Room—Outdoor conditions. Steam, white liquor, black liquor, turpentine-bearing condensates, water.
D Brown Stock Wash Room—Outdoor conditions. Steam, black liquor, hot water.
E Screen Room—Outdoor conditions. Water.
F Size and Alum Plant—Indoor conditions. Water, steam, alkaline solutions (size), acid solutions (alum).
G Jordan Room—Indoor conditions. Water.
H Machine Room—Indoor conditions. Steam, water.
I Finishing Room—Indoor conditions.
J Bag Plant—Indoor conditions.
K Causticizing Plant—Outdoor conditions. Lime, green liquor, white liquor, steam, lime mud.
L Bleach Plant—Indoor conditions. Chlorine, caustic soda, sodium hypochlorite, sulphur dioxide (sodium peroxide), steam, water.
M Evaporator Room—Outdoor conditions. Black liquor, water, steam.
N Recovery Plant—Outdoor conditions. Black liquor, green liquor, salt cake, steam water, fuel oil.
O Machine Shop—Indoor conditions.
P Boiler Room—Indoor conditions. Boiler water treating chemicals, steam, water. Chemical dusts recovery, fuel oil.
Q Turbine Room—Indoor conditions.
R Lime Kiln—Feed end. Outdoor conditions, lime mud, water steam. Discharge end. Indoor conditions, lime, fuel oil. Radiant heat.
S Salt Cake Storage—Indoor conditions. Salt cake.
T Service Pump House—Indoor conditions.
W Bark Burning Boiler House—Outdoor conditions. Same as P.

COMPOSITION OF VARIOUS LIQUORS AND SOLUTIONS

White Liquor:
Total soda as Na_2O—1 lb./gal.
Sodium hydroxide—55
Sodium sulphide—30
Sodium carbonate—15

Green Liquor:
Total soda as Na_2O—1 lb./gal.
Sodium hydroxide—10
Sodium sulphide—30
Sodium carbonate—60

Black Liquor:
Soap soda lignin, sodium salts (in varying ratio and concentration)

Size Emulsion:
Sodium soap of gum or wood rosin, sodium carbonate, free colloidal rosin.

Alum Solution:
Aluminum sulphate—1 lb./gal.

Boiler Treating Chemicals:
Sodium hydroxide
Sodium hexametaphosphate
Sodium chloride
Sodium sulphite

IPCEA Standard S-19-81—Appendix N

ACCELERATED WATER ABSORPTION TEST METHODS FOR RUBBER AND RUBBERLIKE INSULATIONS

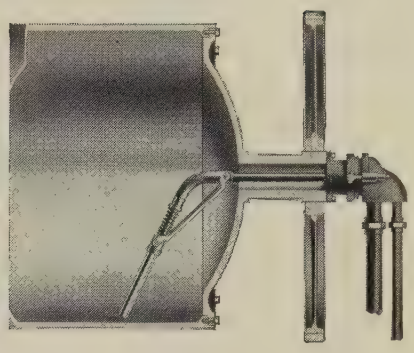
Section 1 Electrical Method

1.1 Test Specimen. A 15-ft. test specimen of the insulated wire shall be taken after vulcanization and prior to the application of any coverings except tape applied before vulcanization. Such tape shall be removed before making the test. After not less than 48 hr. following vulcanization the specimen shall be

Double Barrel Reason

Reaction of ¾" Auto-Flex in 48" dia. dryer. Very low leverage.

Reaction of ¾" ordinary bent pipe. Syphon in 48" dia. dryer. High leverage.



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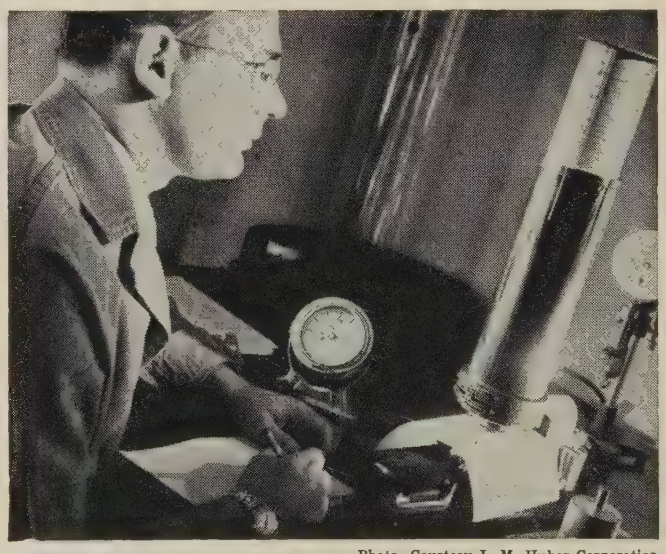

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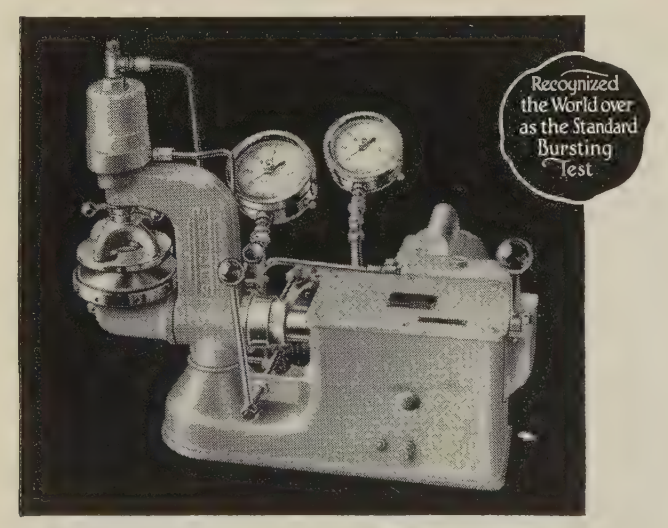

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dried for 24 hr. in air at 70 °C. The specimen shall be allowed to cool in air to approximately 50 °C. before immersion in water.

1.2 Immersion of Specimen. The middle 10 ft. of the test specimen shall be immersed in tap water, maintained at a temperature of 50 ± 1 °C., for a period of 14 days with the 2½-ft. portion of each end kept above water as leakage insulation. A tightly fitting cover should be placed directly above the water surface with suitable water-tight bushings for the ends of the specimen. The water level should be kept constant.

1.3 1000-Cycle Tests. The capacitance of the specimen shall be measured after 1, 7, and 14 days' total immersion with alternating current at a frequency of approximately 1000 cycles. The increase in capacitance from 1 to 14 days, and from 7 to 14 days shall be expressed as a percentage of the 1 and 7-day values, respectively.

1.4 60-Cycle Tests. The capacitance of the specimen shall be measured after 1, 7, and 14 days' total immersion at an average stress of 80 v. per mil, 60 cycles. After 14 days' total immersion the specimen power factor shall be measured at average stresses of 40 and 80 v. per mil, 60 cycles. Each value shall be given to the nearest 0.1 per cent power factor. The increase in capacitance from 1 to 14 days and from 7 to 14 days shall be expressed as a percentage of the 1 and 7-day values, respectively. The difference between the values of percentage power factor at 40 and 80 v. per mil shall be calculated after 14 days in water at 50 °C.

SECTION 2 GRAVIMETRIC METHOD

2.1 Test Specimen. An 11-in. test specimen of the rubber-insulated conductor with all coverings removed shall be used for the test if the weight of such specimen is less than 100 g. For heavier specimens a segment 4 in. in length and 1 in. in width shall be cut from the insulation and buffed to remove all corrugations.

2.2 Procedure. The surface of the test specimens shall be cleaned by scrubbing with lintless cloth moistened with water and dried to constant weight in vacuum over calcium chloride at 70 ± 2 °C. The sample shall be weighed to the nearest milligram, weight, A. The area shall be designated in square inches of a 10-in. length of the wire, or the total area in square inches of the segment, S. The insulated wire shall be bent in the shape of a U around a mandrel not less than three times the diameter of the specimen and the ends shall be inserted in tight-fitting holes in the cover of a 1-pt. glass jar so that 10 in. of the specimen will be submerged when the jar is completely filled with water and the cover applied.

2.3 Immersion of Specimens. The test specimen shall be immersed in freshly boiled distilled water at 70 ± 1 °C. for 168 hr. and the level of the water shall be maintained flush with the under surface of the cover during the soaking period. The segment-shaped specimen should be completely submerged. The water shall be cooled to room temperature. The specimen shall be removed and the adhering water shaken off. The specimen shall be blotted lightly with lintless cloth and weighed within 3 min. to the nearest milligram, weight, B.

The specimen shall be dried in vacuum over calcium chloride at 70 ± 2 °C. to constant weight, C, expressed in milligrams.

2.4 Calculations. All results, in terms of milligrams per square inch of surface, shall be calculated as follows:

$$\text{Water absorption (if } C \text{ is less than } A) = \frac{B - C}{S}.$$

$$\text{Water absorption (if } C \text{ is greater than } A) = \frac{B - A}{S}.$$

$$\text{Water-soluble matter (if } C \text{ is less than } A) = \frac{A - C}{S}.$$

2.5 Recommended Limits for Insulation Thicknesses 3/64 In. and Greater.

(a) Method EM-60—

Increase in dielectric constant 1 to 14 days	10% max.
Increase in dielectric constant 7–14 days	3% max.
* Stability Factor after 14 days	1.0% max.
* Alternate: Stability Factor difference 1–14 days	0.5% max.

(b) Method EM-1000—

Increase in dielectric constant 1–14 days	10% max.
Increase in dielectric constant 7–14 days	3% max.

(c) Method GM—

Moisture absorption after 7 days' immersion in water at 70 °C., Milligrams per sq. in.	20.0% max.

2.6 Applications of Test Methods.

1. Communication Cables—Methods GM and EM-1000
2. Control Cable—Method EM-60
3. Power Cable—Method EM-60

Note: Stability factor is an arithmetical difference between the percentage power factor measured at 60-cycle average

stresses of 80 and 40 volts per mil, respectively, after submersion in water at a temperature of 50 °C. ±1.0 °C. for a specified period.

Table I—Part 3—Voltage Classification and Grades of Insulation

Circuit voltage	*Single-conductor cables* — *Nonleaded*	*Lead covered*	*Multiple conductor cables* — *Nonleaded*	*Lead covered*
0–2000	All grades	All grades	All grades	All grades
2001–5000	All grades except Code grade Type R	All grades	All grades except Code grade Type R	All grades except Code grade Type R
5001 and over	Ozone resistant or manufacturer's recommendations for all constructions			

Grades of insulation referred to in above table are:

Code Grade (Type R).....	Underwriters' Laboratories Type R. (See Appendix A below.)
Performance Grade.....	ASTM Performance Grade D 353 and D 755. (See Appendix B below.)
Heat-Resisting Grade (Type RH).	ASTM Heat-Resisting Insulation D 469 and D 754. Underwriters' Laboratories Type RH. (See Appendix C below.)
Ozone-Resistant Compound (MR)	ASTM Ozone-Resistant Insulation, ASTM D 574. (See Appendix D below.)
Manufacturer's Recommendation.	Special compounds not listed above. Physical and electrical characteristics must be obtained from the manufacturer.
Thermoplastic Polyvinyl-Chloride (PVC).....	ASTM D 734–43 T and Underwriters' Laboratories Thermoplastic Insulation, Type T. 0–600 v. only.

Where type letters are used to indicate the type of wires and cables in accordance with the requirements of the National Electrical Code and the Underwriters' Laboratories, Inc., Standards, the following type letters shall be used:

R —Indicates a single conductor having rubber insulation of Code grade and a nonmetallic covering.
RH—Indicates a single conductor having rubber insulation of heat-resisting grade and a nonmetallic covering.
T —Indicates a single conductor having a thermoplastic insulation, without other coverings.
D —Used as a suffix indicates a twin wire having two insulated nonmetallic covered conductors laid parallel under an outer nonmetallic covering.
M —Used as a suffix indicates a cable having two or more rubber-insulated nonmetallic covered conductors twisted together under an outer nonmetallic covering.
L —Used as a suffix indicates that an outer covering of lead has been applied.

Type letters as given above, when used alone, indicate conductors for use at not more than 600 v. Conductors for use at higher voltages shall be indicated by adding numerical suffices to the type letters as follows:

10—for use at not more than 1000 v.
20—for use at not more than 2000 v.
30—for use at not more than 3000 v.
40—for use at not more than 4000 v.
50—for use at not more than 5000 v.

Appendix A—Code Grade Insulation

This grade of insulation is suitable for operation at conductor temperatures not exceeding 60 °C. When tested in accordance with Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

Recovery.....	2-in. gage marks stretched to	5 in.
	Held for	2 min.
	Rest period	2 min.
	Maximum set	1/2 in.

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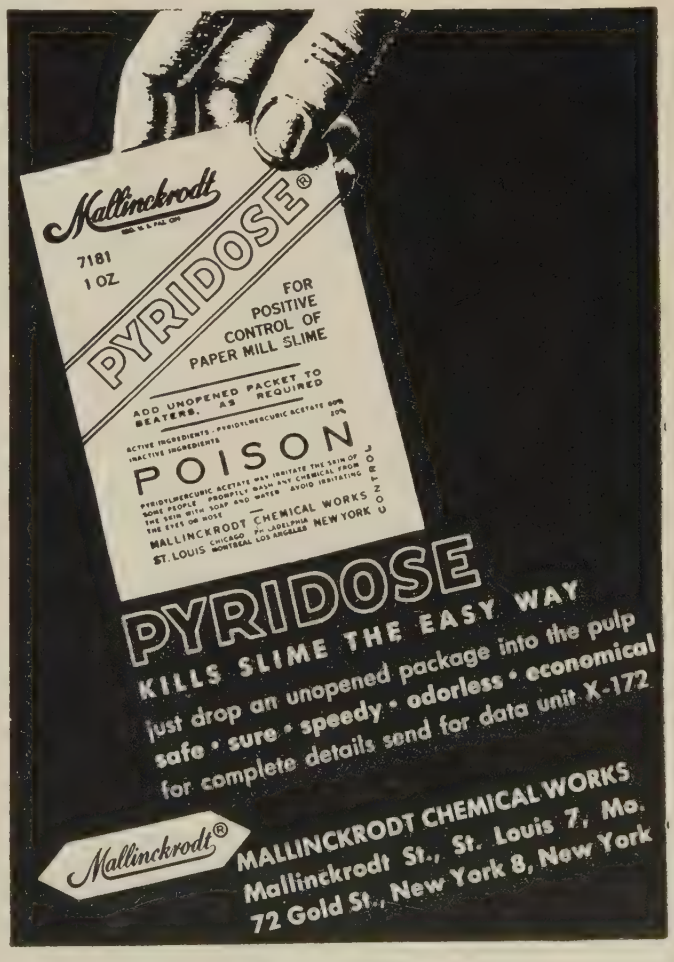
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Thickness of Insulation per IPCEA Standards S-19-81—Table II—Part 3

Insulation Thicknesses and Test Voltages in Kv. for Code, Performance, Heat-Resisting and Ozone-Resistant Grade Compounds (See Table I—Part 3, for Voltage Limitations of Various Grades)

Rated circuit voltage	Size, Awg. or MCM	Insulation thickness, 64ths in. and mils. Neut. grd.	Neut. ungrd.	A.C. test voltages, kv. Code (R) Grd.	Ungrd.	Performance, heat resisting (RH) Grd.	Ungrd.	Ozone resistant Grd.	Ungrd.
0–600	18–16	2 (32)	2 (32)	1.5	1.5	1.5	1.5	1.5	1.5
	14–9	3 (47)	3 (47)	1.5	1.5	3.0[a]	3.0[a]	4.5	4.5
	8	4 (63)	4 (63)	1.5	1.5	3.5	3.5	6.0	6.0
	7–2	4 (63)	4 (63)	2.0	2.0	3.5	3.5	6.0	6.0
	1–4/0	5 (78)	5 (78)	2.5	2.5	4.0	4.0	7.5	7.5
	225–500	6 (94)	6 (94)	3.0	3.0	5.0	5.0	8.5	8.5
	525–1000	7 (109)	7 (109)	3.5	3.5	6.0	6.0	10.0	10.0
	Over 1000	8 (125)	8 (125)	3.5	3.5	7.0	7.0	11.5	11.5
601–1,000	14–8	4 (63)	4 (63)	4.0	4.0	5.0	5.0	6.0	6.0
	7–2	5 (78)	5 (78)	5.0	5.0	6.0	6.0	7.5	7.5
	1–4/0	6 (94)	6 (94)	6.0	6.0	7.5	7.5	8.5	8.5
	225–500	7 (109)	7 (109)	7.0	7.0	9.0	9.0	10.0	10.0
	525–1000	8 (125)	8 (125)	8.0	8.0	10.0	10.0	11.5	11.5
	Over 1000	9 (141)	9 (141)	9.0	9.0	11.0	11.0	13.0	13.0
1,001–2,000	14–8	5 (78)	5 (78)	5.0	5.0	6.0	6.0	7.5	7.5
	7–2	6 (94)	6 (94)	6.0	6.0	7.5	7.5	8.5	8.5
	1–4/0	7 (109)	7 (109)	7.0	7.0	9.0	9.0	10.0	10.0
	225–500	8 (125)	8 (125)	8.0	8.0	11.0	10.0	11.5	11.5
	525–1000	9 (141)	9 (141)	9.0	9.0	11.0	11.0	13.0	13.0
	Over 1000	9 (141)	9 (141)	9.0	9.0	11.0	11.0	13.0	13.0
2,001–3,000	10–8	7 (109)	7 (109)	7.0	7.0	9.0	9.0	10.0	10.0
	7–4/0	8 (125)	8 (125)	8.0	8.0	10.0	10.0	11.5	11.5
	225–1000	9 (141)	9 (141)	9.0	9.0	11.0	11.0	13.0	13.0
	Over 1000	10 (156)	10 (156)	10.0	10.0	12.5	12.5	14.0	14.0
3,001–4,000	10–4/0	9 (141)	9 (141)	9.0	9.0	11.0	11.0	13.0	13.0
	225–1000	10 (156)	10 (156)	10.0	10.0	12.5	12.5	14.0	14.0
	Over 1000	11 (172)	11 (172)	11.5	11.5	13.5	13.5	15.5	15.5
4,001–5,000	8–4/0	10 (156)	10 (156)	10.0	10.0	12.5	12.5	14.0	14.0
	225–1000	11 (172)	11 (172)	11.5	11.5	13.5	13.5	15.5	15.5
	Over 1000	12 (188)	12 (188)	13.0	13.0	15.0	15.0	17.0	17.0
5,001–6,000	8–4/0	10 (156)	12 (188)	...	...	12.5	15.0	14.0	17.0
	225–1000	11 (172)	12 (188)	...	...	13.5	15.0	15.5	17.0
	Over 1000	12 (188)	13 (203)	...	...	15.0	16.5	17.0	18.5
6,001–7,000	8–1000	11 (172)	14 (219)	...	...	13.5	17.5	15.5	20.0
	Over 1000	12 (188)	15 (234)	...	...	15.0	19.0	17.0	21.0
7,001–8,000	8–1000	12 (188)	16 (250)	...	...	15.0	20.0	17.0	22.5
	Over 1000	13 (203)	17 (266)	...	...	16.5	21.0	18.5	24.0
8,001–9,000	6–1000	13 (203)	17 (266)	...	...	16.5	21.0	18.5	24.0
	Over 1000	14 (219)	18 (281)	...	...	17.5	22.5	20.0	25.0
9,001–10,000	6–1000	14 (219)	18 (281)	...	...	17.5	22.5	20.0	25.0
	Over 1000	15 (234)	19 (297)	...	...	19.0	24.0	21.0	26.5
10,001–11,000	6–1000	15 (234)	20 (313)	...	...	19.0	25.0	21.0	28.0
	Over 1000	16 (250)	21 (328)	...	...	20.0	26.5	22.5	29.5
11,001–12,000	6–1000	16 (250)	22 (344)	...	...	20.0	28.0	22.5	31.0
	Over 1000	17 (266)	23 (266)	...	...	21.0	29.5	24.0	32.0
12,001–13,000	6–1000	17 (266)	23 (359)	...	...	21.0	29.5	24.0	32.0
	Over 1000	18 (281)	24 (375)	...	...	22.5	31.0	25.0	33.5
13,001–14,000	6–1000	18 (281)	25 (391)	...	...	22.5	32.5	25.0	35.0
	Over 1000	19 (297)	26 (406)	...	...	24.0	34.0	26.5	36.0
14,001–15,000	6–1000	19 (297)	27 (422)	...	...	24.0	35.5	26.5	37.5
	Over 1000	20 (313)	28 (438)	...	...	25.0	37.0	28.0	39.0
15,001–16,000	4–1000	20 (313)	28 (438)	...	...	...	...	28.0	39.0
	Over 1000	21 (328)	29 (453)	...	...	...	...	29.5	40.5
16,001–17,000	4–1000	21 (328)	30 (469)	...	...	...	...	29.5	41.5
	Over 1000	22 (344)	31 (484)	...	...	...	...	31.0	43.0
17,001–18,000	4–1000	22 (344)	...	...	...	...	...	31.0	...
	Over 1000	23 (359)	...	...	...	...	...	32.0	...
18,001–19,000	4–1000	23 (359)	...	...	...	...	...	32.0	...
	Over 1000	24 (375)	...	...	...	...	...	33.5	...
19,001–20,000	2–1000	24 (375)	...	...	...	...	...	33.5	...
	Over 1000	25 (391)	...	...	...	...	...	35.0	...
20,001–21,000	2–1000	25 (391)	...	...	...	...	...	35.0	...
	Over 1000	26 (406)	...	...	...	...	...	36.0	...
21,001–22,000	2–1000	26 (406)	...	...	...	...	...	36.0	...
	Over 1000	27 (422)	...	...	...	...	...	37.5	...
22,001–23,000	2–1000	27 (422)	...	...	...	...	...	37.5	...
	Over 1000	28 (438)	...	...	...	...	...	39.0	...
23,001–24,000	2–1000	28 (438)	...	...	...	...	...	39.0	...
	Over 1000	29 (453)	...	...	...	...	...	40.5	...
24,001–25,000	2–1000	29 (453)	...	...	...	...	...	40.5	...
	Over 1000	30 (469)	...	...	...	...	...	41.5	...

Thickness of Insulation per IPCEA Standards S-19-81—Table II—Part 3 (*continued*)

Rated circuit voltage	Size, Awg. or MCM	Insulation thickness, 64ths in. and mils. Neut. grd.	Neut. ungrd.	A.C. test voltages, kv,— Performance, heat resisting (RH) Code (R) Grd.	Ungrd.	Grd.	Ungrd.	Ozone resistant Grd.	Ungrd.
25,001–26,000	2–1000	30 (469)	...	...	...	...	...	41.5	...
	Over 1000	31 (484)	...	...	...	...	...	43.0	...
26,001–27,000	1–1000	31 (484)	...	...	...	...	...	43.0	...
	Over 1000	32 (500)	...	...	...	...	...	44.5	...
27,001–28,000	1–1000	32 (500)	...	...	...	...	...	44.5	...
	Over 1000	33 (516)	...	...	...	...	...	46.0	...

[a] Building wire sizes 14 and 12 with $^{2}/_{64}$ in. thicknesses of Type RH insulation shall be tested at 1.5 kv.

Note A: For building wire the National Electric Code permits the use of $^{2}/_{64}$ in. wall of Types R and RH insulations on sizes 14 and 12 Awg. for 600-v. service. For parkway, control cables, and other important circuits, $^{3}/_{64}$-in. wall is recommended.

Note B: The minimum conductor sizes given in each voltage class are not necessarily suitable for all types of cable or conditions of service, where mechanical stresses govern, as for example submarine cables or long vertical risers.

Note C: For thermoplastic insulation thicknesses and test voltages see Appendix I.

Note D: Where the insulated conductor or conductors are covered by rubber or rubber-like impervious sheaths, either integral with the insulation or separate therefrom, or where the thickness of the insulation is increased for mechanical reasons, such as the insulation between conductors of a concentric type cable, the test voltage shall be determined by the size of the conductor and rated voltage of the cable and not by the apparent thickness of the insulation.

Elongation.....	Minimum elongation of 2-in. gage marks at rupture	200% (2–6 in.)
Tensile strength....	Minimum strength at rupture, lb. per sq. in.	500
Aging Requirements (4.2, Part 4)		
	Bomb temperature	69–71 °C.
	Bomb pressure, lb. per sq. in.	290–310
	Time	96 hr.
Oxygen bomb test..	Minimum elongation, % of unaged value	65%
	Minimum tensile strength, % of unaged value	75%

Note: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation $^{1}/_{32}$ in. and greater.

Temperature °F.	°C.	Temperature coefficient	Temperature °F.	°C.	Temperature coefficient
50	10	0.60	66	18.9	1.34
51	10.6	0.63	67	19.4	1.41
52	11.1	0.67	68	20.0	1.48
53	11.7	0.71	69	20.6	1.55
54	12.2	0.75	70	21.1	1.63
55	12.8	0.79	71	21.7	1.71
56	13.3	0.82	72	22.2	1.80
57	13.9	0.86	73	22.8	1.89
58	14.4	0.90	74	23.3	1.98
59	15.0	0.95	75	23.9	2.08
60	15.5	1.00	76	24.4	2.18
61	16.1	1.05	77	25.0	2.29
62	16.7	1.10	78	25.6	2.40
63	17.2	1.16	79	26.1	2.52
64	17.8	1.22	80	26.7	2.65
65	18.3	1.28			

Electrical Tests (4.3, Part 4)

Voltage application for 1 min. at values in Table II, Part 3, see pages 9, 10, 11 of these minutes.

Insulation resistance per 1000 ft. based on a constant of K = 950 at 60 °F. (15.5 °C.).

Note: Electrical tests on this grade of insulation are not required in preliminary state and such test shall be optional with the manufacturer.

When temperature of the water in which insulation is tested differs from 60 °F. (15.5 °C.) multiply the reading obtained by the values given above to obtain the value for 60 °F.

Appendix B—Performance Grade Insulation

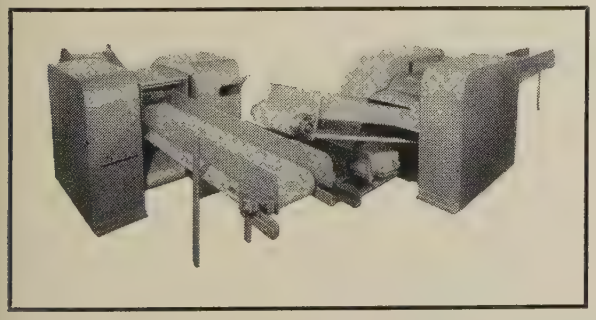
This grade of insulation can be furnished with either synthetic or natural rubber compounds suitable for operation at conductor temperature not exceeding 60 °C.

A—SYNTHETIC RUBBER INSULATION

When tested in accordance with Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

	A	B
Tensile strength, min. lb. per sq. in.	700	600
Elongation at rupture, min. %	300% (2–8 in.)	250% (2–7 in.)
Aging Requirements (4.2, Part 4)		
Oxygen pressure test		
Temperature.....	69–71 °C.	69–71 °C.
Pressure, lb. per sq. in.....	290–310	290–310
Time.....	96 hr.	96 hr.
Minimum elongation, % of unaged value.....	65%	65%
Minimum tensile strength, % of unaged value.....	75%	75%



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Note 1: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation 1/32 in. and greater.

Note 2: When test specimens are taken from finished cables having rubber or other thermosetting sheaths, the values for physical and aging properties shall be as given in Column B.

Electrical Tests (4.3, Part 4)

Voltage test for 5 min.—values as in Table II, Part 3.

Insulation resistance per 1000 ft. based on a constant $K = 2000$ at 60 °F. (15.5 °C.)

Temperature coefficients as given under Electrical Tests, below.

B—NATURAL RUBBER INSULATION

When tested in accordance with Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

		A	B
	2-in. gage marks stretched to	6 in.	6 in.
Recovery....	Held for	5 sec.	5 sec.
	Rest period	1 min.	1 min.
	Maximum set	3/8 in.	3/8 in.
Elongation..	Minimum elongation of 2-in. gage marks at rupture	400% (2–10 in.)	300% (2–8 in.)
Tensile strength...	Minimum tensile strength at rupture, lb. per sq. in.	1200	900
	Elongation of specimen	200% (2–6 in.)	...
Tensile stress.....	Minimum tensile stress, lb. per sq. in.	300	...

Aging Requirements (4.2, Part 4)

	Oven temperature	69–71 °C.	69–71 °C.
	Time	96 hr.	96 hr.
Air oven test.	Minimum elongation, % of unaged value	85%	75%
	Minimum tensile strength, % of unaged value	85%	75%
	Bomb temperature	69–71 °C.	69–71 °C.
	Bomb pressure, lb. per sq. in.	290–310	290–310
	Time	96 hr.	96 hr.
Oxygen bomb test.	Minimum elongation, % of unaged value	75%	65%
	Minimum tensile strength, % of unaged value	75%	65%

Note 1: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation 1/32 in. and greater.

Note 2: When test specimens are taken from finished cables having rubber or other thermosetting sheaths, the values for physical and aging properties shall be as given in Column B.

Electrical Tests (4.3, Part 4)

Voltage application for 5 min. at values in Table II, Part 3.

Insulation resistance per 1000 ft. based on a constant of $K = 10{,}560$ at 60 °F. (15.5 °C.).

When the temperature of the water in which the insulation is tested differs from 60 °F. (15.5 °C.) multiply the reading obtained by the coefficients given below to obtain the value for 60 °F.

Temperature °F.	°C.	*Temperature coefficient*	*Temperature* °F.	°C.	*Temperature coefficient*
50	10.0	0.77	66	18.9	1.17
51	10.6	0.79	67	19.4	1.20
52	11.1	0.81	68	20.0	1.23
53	11.7	0.83	69	20.6	1.26
54	12.2	0.85	70	21.1	1.30
55	12.8	0.88	71	21.7	1.33
56	13.3	0.90	72	22.2	1.37
57	13.9	0.92	73	22.8	1.40
58	14.4	0.94	74	23.3	1.44
59	15.0	0.97	75	23.9	1.48
60	15.5	1.00	76	24.4	1.52
61	16.1	1.03	77	25.0	1.56
62	16.7	1.05	78	25.6	1.61
63	17.2	1.08	79	26.1	1.65
64	17.8	1.11	80	26.7	1.70
65	18.3	1.14			

Appendix C—Heat-Resisting Grade Insulation

This grade of insulation can be furnished with either synthetic or natural rubber compounds suitable for operation at conductor temperatures not exceeding 75 °C.

A—SYNTHETIC RUBBER INSULATION

When tested in accordance with the requirements of Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

		A	B
Tensile strength, min. lb. per sq. in.		700	600
Elongation at rupture, min. %		300% (2–8 in.)	250% (2–7 in.)

Aging Requirements (4.2, Part 4)

Air pressure heat test.....			
	Temperature	126–128 °C.	126–128 °C.
	Pressure, lb. per sq. in.	77–83	77–83
	Time	20 hr.	20 hr.
	Minimum tensile and elongation, % unaged value	50%	50%
Oxygen bomb test.....			
	Temperature	79–81 °C.	79–81 °C.
	Pressure, lb. per sq. in.	290–310	290–310
	Time	168 hr.	168 hr.
	Minimum tensile and elongation, % unaged value	50%	50%

Note 1: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation 1/32 in. and greater.

Note 2: When test specimens are taken from finished cables having rubber or other thermosetting sheaths, the values for physical and aging properties shall be as given in Column B.

Electrical Tests (4.3, Part 4)

Voltage application for 5 min. at values in Table II, Part 3, see pages 9, 10, 11 of these minutes.

Insulation resistance per 1000 ft. based on a constant $K = 2000$ at 60 °F. (15.5 °C.).

Temperature coefficients are given below.

B—NATURAL RUBBER INSULATION

When tested in accordance with the requirements of Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

		A	B
	2-in. gage marks stretched to	6 in.	6 in.
Recovery....	Held for	5 sec.	5 sec.
	Rest period	1 min.	1 min.
	Maximum set	3/8 in.	3/8 in.
Elongation..	Minimum elongation of 2-in. gage marks at rupture	400% (2–10 in.)	300% (2–8 in.)
Tensile strength...	Minimum tensile strength at rupture, lb. per sq. in.	1500	1200
Tensile stress	Elongation of specimen	200% (2–6 in.)	200% (2–6 in.)
	Minimum tensile stress, lb. per sq. in.	400	300
	Bomb temperature	79–81 °C.	79–81 °C.
	Bomb pressure, lb. per sq. in.	290–310	290–310

Aging Requirements (4.2, Part 4)

	Time	168 hr.	168 hr.
Oxygen bomb test (see Note 3)...	Minimum elongation, % of unaged value	75%	65%
	Minimum tensile strength, % of unaged value	75%	65%
	Bomb temperature	126–128° C.	126–128° C.
	Bomb pressure, lb. per sq. in.	77–83	77–83
	Time	20 hr.	20 hr.
	Minimum elongation, % of unaged value	50%	50%
Air pressure heat test..	Minimum tensile strength, % of unaged value	50%	50%

Note 1: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation 1/32 in. and greater.

Note 2: When test specimens are taken from finished cables having rubber or other thermosetting sheaths, the values for physical and aging properties shall be as given in Column B.

Note 3: Oxygen bomb test shall be made as routine acceptance test only when specified by the purchaser.

Electrical Tests (4.3, Part 4)

Voltage application for 5 min. at values in Table II, Part 3.

Insulation resistance per 1000 ft. based on constant $K = 10{,}560$ at 60°F. (15.5°C.).

When the temperature of the water in which the insulation is tested differs from 60°F. (15.5°C.) multiply the readings obtained by the coefficients given below to obtain the value at 60°F.

Temperature °F.	Temperature °C.	Temperature coefficient	Temperature °F.	Temperature °C.	Temperature coefficient
50	10.0	0.73	66	18.9	1.20
51	10.6	0.76	67	19.4	1.24
52	11.1	0.78	68	20.0	1.28
53	11.7	0.80	69	20.6	1.32
54	12.2	0.83	70	21.1	1.36
55	12.8	0.86	71	21.7	1.40
56	13.3	0.88	72	22.2	1.45
57	13.9	0.91	73	22.8	1.50
58	14.4	0.94	74	23.3	1.55
59	15.0	0.97	75	23.9	1.59
60	15.5	1.00	76	24.4	1.64
61	16.1	1.03	77	25.0	1.69
62	16.7	1.07	78	25.6	1.75
63	17.2	1.10	79	26.1	1.80
64	17.8	1.13	80	26.7	1.86
65	18.3	1.17			

Appendix D—Ozone-Resistant Grade Insulation

The requirements of this specification apply to ozone-resistant type insulation for all sizes and classes of single and multiple conductor power cables which are to be used for the transmission and distribution of electrical energy, either underground, submarine, aerial, or indoor, under normal conditions of installation, and operating at not over 17,000 v. between phases on an underground neutral system or 28,000 v. between phases on a grounded neutral system.

The insulation shall consist of a properly vulcanized rubber or rubberlike compound, applied concentrically around the coated copper conductor, and which shall be firm, elastic, and fit tightly to the conductor.

When tested in accordance with Part 4 (below), it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

	2-in. gage marks stretched to	6 in.
Recovery.....	Held for	5 sec.
	Rest period	1 min.
	Maximum set	1/2 in.
Elongation.....	Minimum elongation of 2-in. gage marks at rupture	250% (2–7 in.)
Tensile strength.	Minimum tensile strength at rupture, lb. per sq. in.	450

Aging Requirements (4.2, Part 4)

	Oven temperature	69–71°C.
	Time	168 hr.
Air oven test.....	Elongation, min. %	200% (2–6 in.)
	Tensile strength, min. lb. sq. in.	400
	Bomb temperature	69–71°C.
	Bomb pressure, lb. per sq. in.	290–310
Oxygen bomb test.....	Time	48 hr.
	Elongation, min. %	200% (2–6 in.)
	Tensile strength, min. lb. per sq. in.	400

Note 1: The physical and aging values are applicable to conductors having nominal wall thicknesses of insulation 1/32 in. and greater.

Electrical Tests (4.3, Part 4)

A.C. voltage application for 5 min. at values in Table II, Part 3, see pages 9, 10, 11 of these minutes.

D.C. voltage application—each reel length of insulated conductor for 5001 v. or over, immediately after the insulation resistance test, and while still immersed in water shall withstand without failure for a period of 15 min. a d.c. test equal to not less than 3.0 times the a.c. test voltage.

Insulation resistance per 1000 ft. based on a constant $K = 2000$ at 60°F. (15.5°C.).

When the temperature at which the test is made differs from 15.5°C. a suitable temperature correction factor shall be furnished by the manufacturer.

NEOPRENE SHEATHS PER IPCEA STANDARD S-19-81—THICKNESS IN ACCORDANCE WITH PARAGRAPH 6.3.2.3. AND QUALITY IN ACCORDANCE WITH APPENDIX K

6.3.2.3. Thickness. The average thicknesses shall be not less than those specified in Tables XII, XII-A, XII-B, XIII, or XIV, for the service indicated. The minimum thickness at any point shall be not less than 90% of the specified thickness.

Table XII—Part 6—Single-Conductor Nonshielded Cable—0–5000 V. (for Conduit and Underground Ducts)

Sheath Thicknesses—64ths of an Inch

Size Awg. or MCM	0–600 v.	601–1000 v.	1001–2000 v.	2001–3000 v.	3001–4000 v.	4001–5000 v.
14–9	1	1	1	..	..	..
8	1	1	2	2	2	2
6	2	2	2	2	2	2
4	2	2	2	2	3	3
2	2	2	2	3	3	3
1	3	3	3	3	3	3
1/0	3	3	3	3	3	3
2/0	3	3	3	3	3	3
3/0	3	3	3	3	3	3
4/0	3	3	3	3	4	4
225–1000	4	4	4	4	4	4
1250–2000	5	5	5	5	5	5

Note: A compound-filled tape or a braid may be used between the insulation and sheath on conductor sizes No. 1 Awg. and larger.

Table XII-A—Part 6—Single-Conductor Nonshielded Cable—0–5000 V. (for Aerial and Direct Burial)

Sheath Thicknesses—64ths of an Inch

Size Awg. or MCM	0–600 v.	601–1000 v.	1001–2000 v.	2001–3000 v.	3001–4000 v.	4001–5000 v.
14–9	3	3	3	..	..	..
8	3	3	3	3	3	4
6	3	3	3	4	4	4
4	3	3	3	4	4	4
2	3	4	4	4	4	4
1	4	4	4	4	4	4
1/0	4	4	4	4	4	5
2/0	4	4	4	4	5	5
3/0	4	4	4	5	5	5
4/0	4	5	5	5	5	5
225–300	5	5	5	5	5	5
350	5	5	5	5	5	6
400	5	5	5	5	6	6
450–500	5	5	6	6	6	6
550–900	6	6	6	6	6	6
1000	6	6	6	6	6	7
1250–2000	7	7	7	7	7	7

Note 1: A compound-filled tape or a braid may be used between the insulation and sheath on conductor sizes No. 1 Awg. and larger.

Note 2: Table XII-A is based essentially on Table XII-B and for convenience is given in the same form as Table XII.

Table XII-B—Part 6—Single-Conductor, Metallic-Shielded Cable, All Voltages (for All Uses; Conduit, Underground Duct, Aerial, and Direct Burial)

Diameter of cable under sheath, in.	Thickness of sheath in 64ths of an inch
0.425 or less	3
0.426–0.700	4
0.701–1.050	5
1.051–1.500	6
1.501–2.000	7
2.001–3.000	8
3.001 and larger	9

Table XIII—Part 6—Multiple Conductor Cable (for All Voltages and All Uses)

Diameter of cable under sheath, in.	*Thickness of sheath in 64ths of an inch*
0.425 or less	5
0.426–0.700	6
0.701–1.050	7
1.051–1.500	8
1.501–2.000	9
2.001–3.000	10
3.001 and larger	12

Note 1: Table XIII applies to all-round multiple conductor cables having a common over-all sheath, and to flat twin cables except those given in Table XIV.

Note 2: For flat twin cable, use the major core diameter under sheath to determine sheath thickness.

Table XIV—Part 6—Flat Twin Cable—0–600 V. (for All Uses)

Conductor size, Awg.	*Thickness of sheath in 64ths of an inch*
14–12	3
10–6	4
4–1	5
1/0–4/0	6

Appendix K—Oil-Resisting GR-M (Polychloroprene) Sheath—Grade 1

This type of sheath is a vulcanized synthetic rubber composition (type GR-M) suitable for use as an outside covering on insulated electrical cords and cables requiring a sheath for heavy duty service.

When tested in accordance with Part 4 (below), and the oil test procedure given in this appendix, it shall meet the following requirements:

Physical Properties (4.1.1, Part 4)

	2-in. gage marks stretched to	6 in.
Recovery....	Held for	5 sec.
	Rest period	1 min.
	Maximum set	3/8 in.
Elongation..	Minimum elongation of 2-in. gage marks at rupture	300% (2–8 in.)
Tensile strength...	Minimum tensile strength at rupture, lb. per sq. in.	1800
	Elongation of specimen	200% (2–6 in.)
Tensile stress	Minimum tensile stress, lb. per sq. in.	500

Aging Requirements (4.2, Part 4)

	Oven temperature	69–71°C.
	Time	168 hr.
Air oven test.	Elongation, min. %	250% (2–7 in.)
	Tensile strength, min. lb. per sq. in.	1600
	Bomb temperature	69–71°C.
	Bomb pressure, lb. per sq. in.	290–310
Oxygen bomb test.	Time	96 hr.
	Elongation, min. %	250% (2–7 in.)
	Tensile strength, min. lb. per sq. in.	1600

Oil Resistance

	Oil temperature	249–251°F.
	Time	18 hr.
*Oil test....	Minimum elongation, % of unaged value	60%
	Minimum tensile strength, % of unaged value	60%

* Oil Test: Dumbbell specimens shall be prepared before immersion in oil by buffing both sides of the specimen. The dimensions of the specimen shall be not less than 0.125 in. in width, 0.025 in. in thickness, and 1.00 in. in length between bench marks. The specimen shall then be immersed in the oil specified below for 18 hr. at a temperature of 250°F. ± 1°F. At the end of this period the specimen shall be removed from the oil and excess oil removed. The specimen shall be tested within 1 to 4 hr. after removal from the oil for tensile strength and elongation. The calculation for tensile strength shall be based on the area of the specimen obtained before immersion in the oil. The elongation shall be based on bench marks applied to the specimen before immersion in the oil.

The general characteristics of the oil shall be as follows:

Requirement				*ASTM designation*
ASTM color number, max.	...	...	3	D 155
Condition	...	...	Clear	...
Flash point, min.	235°C. 454°F.	...	...	D 92
Fire point, min.	280°C. (536°F.)	...	...	D 92
Free sulphur, max. %	...	...	None	...
Neutralization number, mg. of KOH per g.	...	...	0.020	D 663
Pour point, max.	−5°C. (+23°F.)	...	...	D 97
Specific gravity at 60°F., min.	...	...	0.93	D 287
Total sulfur, max. %	...	...	0.35	D 129
Viscosity, sec.				
At 30°C. (86°F.) Saybolt Furol	...	550 to 650	...	D 88
At 100°C. (212°F.) (Saybolt Universal)	...	95 to 105	...	D 88

Note: The physical, aging, and oil resistance are applicable to nominal sheath thicknesses 1/32 in. and greater.

PART 4—TEST METHODS

4.1.1 Physical Tests.

Physical tests include the determination of tensile strength, tensile stress, ultimate elongation, and permanent set.

4.2.1 Sampling for Aging Tests.

Samples shall be selected in accordance with 4.1.2 and 4.1.3 (below).

4.2.2 Aging Test Specimens.

(a) Test specimens of similar size and shape shall be prepared from each sample selected in accordance with 4.1.2, three for the determination of the initial or unaged properties, and three for aging test required for the grade of insulation being tested. One specimen of each three shall be tested and the other two held as spares except that where only one sample is selected all three specimens shall be tested and the average of the results reported.

(b) In the case of wires and cables smaller than No. 6 Awg. with an insulation thickness less than 6/64 in., the insulation shall be heated in the oxygen bomb and Geer oven without removing the conductor.

(c) In the case of wires and cables of No. 6 Awg. and larger or with an insulation thickness of 6/64 in. or greater, samples shall be cut from the insulation with a cross section not greater than 0.025 sq. in.

(d) Die-cut specimens shall be buffed before being subjected to the accelerated aging tests wherever the thickness of the specimen is 6/64 in. or greater after buffing.

(e) The test specimens shall be suspended vertically in such a manner that they are not in contact with each other or with the sides of the bomb or oven.

(f) Physical tests on both the aged and unaged specimens shall be made at the same time, at a temperature of 24° ± 8°C.

(g) The aged specimens shall have a rest period of not less than 16 hr. nor more than 48 hr. between the completion of the aging and determination of physical properties.

4.2.3 Oxygen Pressure Test.

The test specimens shall be heated in an atmosphere of oxygen at a pressure of 290 to 310 lb. per sq. in. at the temperature and for the period specified for the grade of insulation being tested. The weight of the insulation in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate requiring at least 2 min., when specimens are removed. The bomb temperature shall be recorded automatically on a chart, and controlled to ±1°C.

4.2.4 Air Oven Test.

The test specimens shall be heated at the required temperature for the specified period in an oven having free circulation of fresh air. The oven temperature shall be recorded automatically on a chart, and controlled to ±1°C.

4.2.5 Air Pressure Heat Test.

The test specimen shall be heated in air at the required pressure and temperature for the specified period. The air bomb test shall be conducted in a steam-jacketed vessel or other suit-

able and uniformly heated chamber. The bomb shall be so regulated that the temperature inside the chamber shall reach the test temperature within 15 min. after inserting the test specimens. The air shall be substantially free from oil and moisture. The weight of the insulation in the bomb shall be not over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least 2 min., when specimens are removed. The bomb temperature shall be recorded automatically on a chart, and controlled to ±1°C.

4.2.6 Retests.

If any specimen fails to conform to the values which may be specified for any test, either before or after aging, that test shall be repeated on two additional specimens from the same sample. If both additional specimens conform to the specified values the sample shall be considered to have met the requirements.

4.2.7 Failure and Rejections.

Where a sample selected in accordance with 4.1.3 and representing a quantity of 50,000 ft. or less, fails to meet the physical or aging requirements, the length from which the sample was removed may be rejected. Two additional samples shall be taken from other lengths of the same group and be subjected to the same tests. If either of these samples fails, the coils, reels, or lengths of the group which they represent, may be rejected. If both of these samples meet the tests satisfactorily, the lot or group which they represent shall be accepted, except the length which may have been rejected because of the failure of the first sample.

4.2.8 Resubmission of Wire or Cable.

Rejection of wire or cable under this section shall not debar manufacturer from resubmitting, for inspection and such tests 12 under this specification as the purchaser may designate, all or any part of the rejected lot or group of cables.

4.1.2 Sampling.

(a) Number of samples: Wire and cable shall be sampled as follows:

For sizes less than 250,000 circular mils, one sample shall be selected for each quantity ordered between 2000 and 50,000 ft. of wire or cable and one additional sample for each additional 50,000 ft. thereafter. No sample shall be selected from lots of less than 2000 ft.

For sizes 250,000 circular mils and over, one sample shall be selected for each quantity ordered between 1000 and 25,000 ft. of wire or cable and one additional sample for each additional 25,000 ft. thereafter. No sample shall be selected from lots of less than 1000 ft.

(b) Length of samples: Samples shall be at least 6 ft. in length when the wire size is less than 250,000 circular mils, and at least 12 ft. in length when the wire size is 250,000 circular mils or over.

4.1.3 Test Specimens.

(a) Number of specimens: From each of the samples selected in accordance with 4.1.2 test specimens shall be prepared as follows:

	No. of test specimens
For determination of initial properties (unaged):	
Tensile strength, tensile stress, and ultimate elongation	
Permanent set	3
For accelerated aging tests:	
Air pressure heat or oxygen pressure	3
Air oven	3

One specimen of each three shall be tested and the other two specimens held in reserve except that when only one sample is selected all three specimens shall be tested and the average of the results reported.

(b) Size of specimens: In the case of wire and cable smaller than No. 6 Awg. having an insulation thickness of $^{6}/_{64}$ in. or less, the test specimen may be the entire section of the insulation. When the full cross section is used, the specimens shall not be cut longitudinally. In the case of wire and cable of No. 6 Awg. and larger, or in the case of wire and cable smaller than No. 6 Awg. having an insulation thickness greater than $^{6}/_{64}$ in., specimens approximately square in section, with a cross section not greater than 0.025 sq. in. shall be cut from the insulation. In extreme cases, it may be necessary to use a segmental or sector-shaped specimen.

(c) Preparation of specimens: The test specimen shall have no surface incisions and be as free as possible from other imperfections. Where necessary, surface irregularities such as corrugations due to stranding, etc., may be removed by buffing. When a test specimen is buffed, care shall be taken to make it smooth and of uniform thickness.

(d) Condition and age: Samples of insulated wire or cable for physical and accelerated aging tests shall be taken after vulcanization and prior to the application of any covering except those applied before vulcanizing. No tests shall be made within 24 hr. nor later than 60 days after vulcanization unless agreed to by the manufacturer. Specimens shall not be heated, immersed in water, or subjected to any mechanical or chemical treatment not specifically prescribed in these methods. Specimens for accelerated aging tests having covering applied prior to vulcanization shall be aged with such covering removed.

IPCEA STANDARD S-19-81—THICKNESS IN ACCORDANCE WITH COLUMN B OR COLUMN C WHICHEVER IS APPLICABLE TO CONDITIONS OF INSTALLATION AND QUALITY IN ACCORDANCE WITH APPENDIX I

Table I—Appendix I—Thickness of Conductor Insulation on Single-Conductor Cable and Individual Conductors of MultiConductor Cable

Size Awg. or MCM	*Thickness in 64ths of an inch*		
	Column A	*Column B*	*Column C*
18–9	2	3	4
8	3	4	5
7–2	4	4	5
1–4/0	5	5	6
225–500	6	6	7
525–1000	7	7	8
Over 1000	8	8	9

Column A thicknesses are for use on wire and cables installed in appliances and apparatus, in recognized metal raceways, or where used for supervisory control systems, etc.

Column B thicknesses are for station control wires and cables or similar important circuits or for other installations where a heavier wall on 18 to 8 Awg. is desired than specified in Column A.

Column C thicknesses are for underground ducts and direct earth burial. These thicknesses apply to single-conductor cable, and to the individual conductors of multiple conductor cable which do not have a common sheath over the assembly. In the case of single-conductor cable, the total wall thickness may be of one thermoplastic compound or two compounds (insulation covered with a thermoplastic sheath) at the option of the manufacturer.

Heavier thicknesses for cable covered by Column C may be advisable where service conditions are unusually severe.

Lead-covered cables buried in the ground shall have suitable mechanical protection in accordance with Part 6, below.

Section 6.4 Metallic Coverings—Divisions I, II, and III.

Division I—Materials, construction, and requirements for metallic coverings recommended for use under all ordinary conditions of installation, operation, and maintenance of insulated power and lighting circuit wires and cables.

Division II—Round wire armor for types of cable designed for special or unusual service conditions.

The recommendations contained in Division II are given as a general guide, but the final details of design should be based upon an understanding between the purchaser and the cable manufacturer.

If unusual installation, operating, or maintenance conditions as given by the purchaser are to be met, engineering judgment based upon full information relative to the particular installation should take precedence over these recommendations.

Division III—Round wire armor for Buried Cable.

Division I

Specifications for Metallic Coverings and Accompanying Fibrous Beddings and Protective Coverings for Application to Insulated Electric Cable.

6.4.1 Scope.

These specifications apply to the metallic coverings described in the following sections, together with the necessary fibrous beddings and protective coverings; to nonmetallic coverings over lead sheath; and to their application to insulated electric cable.

6.4.1.1 Lead sheath.

Used with or without supplementary protection when an impervious covering is required.

(a) Quality. A sheath consisting of commercially pure lead, unless an alloyed sheath is specified by the purchaser, shall be

formed tightly around the cable core. The lead used for the sheath shall be obtained in pig form, properly branded, and shall conform to ASTM "Standard Specification for Pig Lead," latest revision of Designation B 29 except that the lead shall be not less than 99.85% pure.

(b) Alloy Sheath. If an alloy sheath is specified there shall be added to the commercially pure lead an alloying element of the kind and to the percentage specified.

Note: The alloying elements most commonly added to lead for cable sheath are 2% tin or $^3/_4$% antimony, by weight.

The tolerances for these are:

	Minimum	*Maximum*
Tin	1.8%	2.2%
Antimony	0.7%	0.9%

(c) Thickness. The average thickness of the lead sheath shall be not less than that specified by the purchaser. The minimum thickness shall in no case be less than ninety (90) per cent of the specified thickness. Average thicknesses representative of good practice for normal conditions of installation are shown in Table XV.

Table XV—Part 6—Thickness of Lead Sheath

Diameter under lead sheath, in.	*Thickness of lead sheath 64ths Inch*	*Mils*
0 –0.425	3	47
0.426–0.700	4	63
0.701–1.050	5	78
1.051–1.500	6	94
1.501–2.000	7	109
2.001–3.000	8	125
3.001 and larger	9	141

On NEC 600-v. building wire, $^2/_{64}$-in. lead is permitted on 14 and 12 Awg. single conductor, and on 14 Awg. two conductor.

The thickness of lead sheath for flat twin cable shall be that corresponding to the major core diameter.

There are special cases where the above thicknesses should be increased, especially on the smaller sizes of cable, if several cables are to be pulled in together in one duct; the sections are extra long; the handling is severe or awkward during installation as in some transformer vaults.

For submarine cable the thickness of the sheath shall be in accordance with the above table except that the thickness for the first two diameter classifications shall be $^5/_{64}$ in. (78 mils).

(d) Measurement of lead thickness. The thickness of the lead shall be determined by measurements made with a micrometer caliper directly on two specimens of lead removed from the cable, one from each end of the reel length. At least five separate measurements, approximately equally spaced around the circumference, shall be made on each specimen and the average of all of the measurements on the two specimens shall be considered the minimum thickness of the lead.

Specimens of lead removed for the purpose of determining dimensions shall be free from external mechanical injury, not less than 3 in. long, with ends cut perpendicular to the axis, and shall be taken at the place of manufacture.

UNDERWRITERS' TYPE AVA OR ACV FOR DRY LOCATION

UNDERWRITERS' TYPE AVL OR VCL FOR WET LOCATION

AVA— Impregnated Asbestos and Varnished Cambric Insulation with Asbestos Braid.

ACV— Varnished Cambric Insulation with Interlocked Metallic Tape Covering.

AVL— Impregnated Asbestos and Varnished Cambric Insulation with Lead Sheath.

VCL— Varnished Cambric Insulation with Lead Covering.

Ozone-Resistant Rubber Insulation IPCEA Standard S-19-81—Section 4.4 and Appendix D, and Appendix N for Moisture Resistance

Section 4.4 Additional Tests Applicable to Ozone-Resistant Insulation Only.

4.4.1 Sample Tests.

4.4.1.1 Selection of samples.

(a) Short-time and long-time dielectric strength tests, capacity tests, and power factor tests shall be made, when required, on selected samples of cable rated at 5001 v. or more. Ozone resistance tests shall be made on cables insulated for any voltage.

(b) The capacity test and power factor test may be made on a single sample.

(c) Samples for the ozone resistance test shall be selected from the finished cable and at a point not less than 5 ft. from the end of the reel or coil to be tested. Where protective coverings are applied, such coverings shall be removed when nonadherent to the insulation. However, where tapes or sheaths are applied directly to the insulation prior to vulcanization and left in place during vulcanization and are consequently adherent to the insulation in the completed cable, such coverings shall not be removed.

Specimens shall be bent, without twisting, at room temperature but not less than 20°C., around a mandrel having a diameter determined from the maximum diameter of the unbent specimen as follows:

Maximum diameter of unbent specimen, in.	*Ratio of mandrel diameter to cable diameter*
Less than 0.500	4
0.500 but less than 0.750	5
0.750 but less than 1.125	6
1.125 but less than 1.750	8
1.750 and larger	10

Two samples shall be taken for this test. One sample shall be bent around a mandrel and through the angle specified hereinafter. The other sample shall be similarly bent but in the reverse direction.

Samples shall not be heated, immersed in water, or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications. Samples at room temperature shall be placed in the ozone testing chamber in not less than thirty (30) nor more than forty-five (45) minutes after bending.

(d) One sample shall be removed for each of these tests per 10,000 ft. or fraction thereof of each construction of cable, to be manufactured. Tests on items of less than 10,000 ft. will be made only when requested in inquiry.

(e) The purchaser shall make provision for the samples in specifying shipping lengths prior to the time manufacture is begun. Requests for additional test samples after manufacture has begun will result in unavoidable length shortage.

(f) The net length of any sample under test in all cases shall be not less than 10 ft. except for the ozone resistance test. The gross length of test samples shall be as follows:

Length of Test Samples, Ft.

	Short-time dielectric strength	*Long-time dielectric strength and bending*	*Capacity and power factor*	*Ozone resistance*
5.0 kv. and less	None	None	None	7.5
5.1–17 kv., inc.	17	13	13	10.0
17.1–28 kv., inc.	22	17	17	10.0

(g) Samples used for the short-time dielectric strength test may be taken either from cable in process or from the completed cable at the manufacturer's option.

Samples for the capacity and power factor tests shall be taken in the preliminary stage described in 4.3.1 (A), below.

Samples for the long-time dielectric strength tests shall be taken from the completed cable.

(h) The frequency of the test voltage shall be between 25 and 100 cycles per sec. The voltage wave shall approximate as closely as possible a sine wave. The source of energy shall be of ample capacity to maintain the required testing potentials throughout testing.

(i) Adequate facilities for making all tests shall be provided by the manufacturer.

4.4.1.2 Short-time dielectric strength test.

(a) A ten (10)-foot test section, plus the necessary test ends, of the insulated or insulated and taped conductor, with all other outer coverings removed, shall be immersed in water at room temperature for a period of at least 1 hr. previous to testing.

(b) After the sample has been immersed for the specified period of time, it shall be subjected to, and shall not fail at a test voltage the value of which shall be twice routine factory a.c. test voltage for a period of five (5) minutes.

The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100% in 10 sec. nor less than 100% in 60 sec.

(c) Starting with the voltage at which the test prescribed in 4.4.1.2 (b), below, was made, the voltage shall be raised, in steps of approximately twenty (20) per cent of the immediately preceding voltage, until failure occurs, the voltage to be kept constant at each step for five (5) minutes.

Note: The test described in paragraph 4.4.1.2 (c) is to be used as an information test and not as an acceptance test.

4.4.1.2 (A) Failure of samples.

(a) If all the samples pass the prescribed tests, the lot of cable to which they apply shall be considered acceptable so far as these particular requirements are concerned.

(b) If any sample fails to pass these tests, the length of cable from which the sample was taken may be rejected and another sample shall then be taken from each of two other lengths of cable in the lot of cable under test. If either such second samples fails to pass the test the lot may be rejected. If both such second samples pass the test the lot of cable (except the length which may have been rejected because of failure of the first sample) shall be accepted.

(c) Failure of any cable length shall not debar the manufacturer from resubmitting the same length of cable for inspection providing that it be so designated.

4.4.1.3 Cold bending and long-time dielectric strength test.

(a) A ten (10)-foot test section, plus the necessary test ends, of the completed cable shall, after subjection to a temperature of minus ten (−10°) degrees Centigrade for not less than two (2) hours, be immediately bent 180 degrees around a cylindrical mandrel and then straightened. It shall then be bent 180 degrees around the mandrel in the opposite direction. The cable shall be so held during bending operations that it cannot revolve around its own axis.

(b) The diameter of the mandrel shall be determined by the following table:

Thickness of conductor insulation, 64th of an inch	*Mandrel diameter as a multiple of over-all cable diameter*	
	Up to 500 MCM	*500 MCM and over*
10–12	8	10
13–20	10	12
21 and over	12	12

(c) Immediately following the bending test, and while still bent, the cable shall be subjected to and shall not fail at factory a.c. test potential for a continuous period of two (2) hours. Potential shall be applied between each conductor and all of the other conductors and also between each conductor and an enclosing grounded surface.

Three conductor cables may be tested with grounded 3-phase voltage or with single-phase voltage. For shielded cables the shields shall be grounded. Unshielded cables shall be tested in a grounded water bath or in a foil, at the manufacturer's option.

4.4.1.3 (A) Failure of samples.

(a) If all of the samples pass the prescribed tests, the lot of cable to which they apply shall be considered acceptable so far as these particular requirements are concerned.

(b) If any sample fails to pass these tests, that length of cable from which the sample was taken shall be rejected and another sample shall then be taken from each of two other lengths of cable in the lot of cable under test. If either such second sample fails to pass the test the lot shall be rejected. If both such second samples pass the test the lot of cable (except the length which was rejected because of failure of the first sample) shall be accepted.

(c) Failure of any cable length shall not debar the manufacturer from resubmitting the same length of cable for inspection providing that it be so designated.

4.4.1.4 Capacity and power factor tests.

After twenty-four (24) hours' submersion in water the sample for capacity and power factor tests shall be tested with suitable 60-cycle equipment at room temperature at working voltage, and shall show a specific inductive capacity of not exceeding 5.0 and a power factor not exceeding 5%.

4.4.1.5 Ozone resistance test.

(a) The specimen shall be exposed to a circulating current of dry air at a temperature of 25° ± 5°C. and having an ozone concentration of not less than 0.010 nor more than 0.015% by volume.

Note: The equipment is shown in the sketch on page 8, Part 4, of IPCEA Standards S-19-81. The equipment is described and the method of determining the ozone concentration is to be found on pages 7, 9, and 10 of the same part and the same Standards.

(f) Acceptance. Samples tested in accordance with the above procedure shall show no injury to the insulation after exposure of three (3) hours.

If all of the samples pass the prescribed test the lot* of cable to which they apply (i.e., all cable submitted up to the group containing the next set of samples—presumably 10,000 ft.) shall be considered acceptable so far as these particular requirements are concerned unless the purchaser requests additional confirmatory tests. In that case additional samples (second samples) shall be taken from reel lengths designated by the purchaser and if they pass the prescribed test, the lot of cable shall be accepted. If any second sample fails to pass the test made on it, the length from which it was removed shall be rejected and a third sample (or samples) shall be selected from a reel length designated by the purchaser in the same group. If all such third samples pass the prescribed test, the lot shall be accepted so far as these particular requirements are concerned, but if any sample fails, the group* involved shall be rejected and no more cable on that order shall be accepted until this test has been successfully passed by samples selected from the next group or groups.

If any sample of those originally selected fails to pass the prescribed test, the length from which the sample was removed shall be rejected and another sample (second samples) shall be taken from another length of cable to be designated by the purchaser and tested. If any such second sample fails to pass the prescribed tests, the group* involved shall be rejected. If all of such second samples pass, then another sample (third samples) shall be taken from a length designated by the purchaser. If all such third samples pass the prescribed test the lot* of cable which the sample represents shall be accepted (except the section which was rejected because of failure of the first sample). If any one fails, the group* from which the samples were taken shall be rejected and no more cable on that order shall be accepted until this test has been successfully passed by samples selected from the next group or groups.

Rejection of cable under this section shall not debar the manufacturer from resubmitting for inspection all or any part of a rejected lot of cable (except lengths from which samples were taken and which failed). However, when such cable is resubmitted, the purchaser or his representative shall be informed as to its identity.

Section 4.3 Electrical Tests.

4.3.1 High-Voltage Tests.

The high-voltage test shall be made with alternating potential (unless d.c. testing is agreed upon) from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine wave.

The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100% in 10 sec. nor less than 100% in 60 sec.

The duration of test for Code grade insulation shall be 1 min.; for higher grades, 5 min. See Table II, Part 3.

(A) Preliminary Tests. Each reel length of insulated conductor that is not to be individually covered with a vulcanized rubber or rubberlike sheath shall be immersed, after vulcanization, in water in a grounded tank. After not less than 6 hours' immersion and while still immersed, each reel of insulated conductor shall withstand without failure a test voltage as required in Table II, Part 3, except that spark testing may be used for cable rated 0–600 v. where agreed upon by manufacturer and purchaser. Any insulated conductor individually covered with a vulcanized sheath, with or without a compound-filled tape or braid between insulation and sheath, shall be tested as above only after the vulcanization of the sheath. (See Note 2.)

Note 1: Electrical tests on Code grade insulation are not required in preliminary state and such tests are optional with the manufacturer.

Note 2: Test voltages for all grades of insulation are given in Table II, Part 3. Where insulated conductor or conductors are covered by rubber or rubberlike impervious sheaths, either integral with the insulation or separate therefrom, or where the thickness of the insulation is increased for mechanical reasons, such as the insulation between conductors of a concentric type cable, the test voltage shall be determined by the size of the conductor and rated voltage of the cable and not by the apparent thickness of the insulation.

(B) Completed Cable Tests. (1) Nonshielded cables without lead sheath: (a) Single-conductor cables with fibrous cover-

* For the purpose of these specifications, a "group" shall be all of the cable designated as such on a list to be submitted by the manufacturer prior to being offered for inspection (not less than 10 reel lengths in 3 successive working days) and a "lot" shall be all of the cable represented by the samples taken for the test prescribed (approximately 15,000 ft.).

ing or with rubber, rubberlike, or thermoplastic sheaths. The preliminary test specified in Section 4.3.1 (A) shall not be repeated and shall be the final test.

(b) Multiple conductor cables without rubber, rubberlike, or thermoplastic sheath. After assembly and final covering each conductor shall be tested against the adjacent grounded conductors without immersion in water at the voltage specified in Table II, Part 3, except armored cables which shall be tested at 80% of the voltage required before armoring.

(c) Multiple conductor cables with rubber, rubberlike, or thermoplastic sheath. After assembly and final covering each conductor shall be tested against adjacent conductors and ground after immersion in water as required by paragraph (A).

(2) Shielded or leaded cables: All cables shall be tested at the a.c. voltage specified in Table II, Part 3, or at a d.c. voltage (see paragraph D below) between conductors and/or to ground, except that in the case of armored cables the a.c. or d.c. test shall be repeated after armoring at 80% of the values required before armoring.

At the option of the manufacturer above tests may be made with or without immersion in water.

(C) Test Voltage After Installation. Immediately after installation, metallic armored (except submarine cable), lead sheathed, shielded, or cables installed entirely on insulators may be tested at a voltage not exceeding 80% of the final factory test voltage applied for the standard time.

It is recommended that no a.c. test be made on nonmetallic covered unshielded cables because of danger of damage to the cables from ozone action or discharges on the cable surface. If an a.c. test is required, cables to be operated at 600 v. or less may be tested at 80% of the final factory test, but not exceeding 2000 v. for the standard time.

(D) High-Voltage D.C. Testing. If a d.c. test is made it shall be made after the insulation resistance test and the ratio of d.c. to the equivalent RMS a.c. voltage shall be not less than 2.2 for nonozone-resistant and not less than 3.0 for ozone-resistant compounds.

4.3.2 Insulation Resistance.

The insulation resistance shall be measured after the preliminary and after the final high-voltage a.c. test. Where the high-voltage tests are made on a wire or cable immersed in water the insulation resistance shall be measured while still immersed. The measurement shall be made after 1 min. electrification with a continuous e.m.f. of from 100 to 500 v., the conductor being maintained negative to the water. The temperature of the water

Appendix G—Values of Log D/d

Wire size, Awg. or MCM	*Insulation thickness, in.*															
	3/64	4/64	5/64	6/64	7/64	8/64	9/64	10/64	11/64	12/64	13/64	14/64	15/64	16/64	17/64	
14[a]	0.392	0.470	0.537	0.594	0.645	0.691	0.732	0.770	0.804	0.836	0.866	0.894	0.921	0.945		
12[a]	0.334	0.405	0.467	0.520	0.568	0.611	0.651	0.686	0.720	0.751	0.779	0.806	0.832	0.856		
10[a]	0.283	0.348	0.404	0.453	0.498	0.538	0.575	0.609	0.641	0.670	0.698	0.723	0.748	0.771	0.793	
8[a]	0.239	0.296	0.347	0.392	0.432	0.470	0.505	0.537	0.566	0.594	0.621	0.645	0.669	0.691	0.712	
6		0.225	0.267	0.305	0.430	0.373	0.403	0.431	0.453	0.483	0.506	0.529	0.550	0.570	0.590	
5		0.206	0.245	0.281	0.314	0.346	0.373	0.401	0.426	0.450	0.463	0.515	0.515	0.535	0.554	
4		0.187	0.224	0.257	0.289	0.318	0.345	0.371	0.395	0.418	0.440	0.460	0.480	0.500	0.517	
3		0.171	0.204	0.236	0.265	0.293	0.318	0.343	0.366	0.388	0.409	0.429	0.448	0.466	0.483	
2		0.155	0.186	0.215	0.243	0.269	0.293	0.316	0.338	0.359	0.379	0.398	0.416	0.433	0.450	
1		0.139	0.168	0.195	0.220	0.244	0.267	0.288	0.309	0.328	0.347	0.365	0.382	0.399	0.415	
0		0.126	0.152	0.177	0.201	0.223	0.244	0.264	0.284	0.302	0.320	0.337	0.354	0.369	0.385	
00		0.114	0.138	0.161	0.183	0.204	0.223	0.242	0.261	0.278	0.295	0.311	0.327	0.342	0.356	
000		0.102	0.125	0.146	0.166	0.185	0.204	0.221	0.238	0.255	0.271	0.286	0.301	0.315	0.329	
0000		0.0923	0.113	0.132	0.151	0.168	0.187	0.202	0.218	0.233	0.248	0.262	0.276	0.289	0.302	
250		0.0854	0.104	0.123	0.140	0.157	0.173	0.189	0.204	0.218	0.232	0.246	0.259	0.272	0.284	
300		0.0787	0.0963	0.113	0.130	0.145	0.160	0.175	0.189	0.203	0.216	0.229	0.250	0.254	0.266	
350		0.0731	0.0897	0.106	0.121	0.136	0.150	0.164	0.177	0.190	0.203	0.215	0.227	0.239	0.250	
400		0.0688	0.0845	0.0995	0.114	0.128	0.142	0.155	0.168	0.181	0.193	0.204	0.216	0.227	0.236	
450		0.0638	0.0801	0.0944	0.108	0.122	0.136	0.148	0.160	0.172	0.184	0.195	0.206	0.217	0.227	
400		0.0620	0.0763	0.0901	0.103	0.116	0.129	0.141	0.153	0.165	0.176	0.187	0.198	0.208	0.218	
550		0.0593	0.0730	0.0862	0.0990	0.112	0.124	0.135	0.147	0.158	0.168	0.180	0.190	0.200	0.210	
600			0.0700	0.0853	0.0952	0.107	0.119	0.130	0.141	0.152	0.163	0.173	0.183	0.193	0.203	
650			0.0674	0.0798	0.0919	0.104	0.115	0.126	0.137	0.147	0.158	0.168	0.178	0.187	0.196	
700			0.0686	0.0769	0.0888	0.100	0.111	0.122	0.133	0.143	0.153	0.163	0.172	0.181	0.191	
750			0.0665	0.0749	0.0861	0.0971	0.108	0.118	0.129	0.139	0.148	0.157	0.167	0.176	0.185	
800			0.0644	0.0727	0.0836	0.0943	0.105	0.115	0.125	0.135	0.144	0.154	0.163	0.172	0.180	
900			0.0580	0.0687	0.0793	0.0895	0.0994	0.108	0.120	0.128	0.137	0.146	0.155	0.164	0.172	
1000			0.0551	0.0656	0.0755	0.0851	0.0948	0.104	0.113	0.122	0.131	0.140	0.148	0.157	0.165	
1250			0.0500	0.0590	0.0681	0.0770	0.0856	0.0943	0.103	0.111	0.119	0.127	0.134	0.142	0.150	
1500			0.0456	0.0541	0.0625	0.0708	0.0789	0.0870	0.0946	0.102	0.110	0.116	0.125	0.132	0.139	
1750			0.0423	0.0502	0.0581	0.0658	0.0734	0.0810	0.0899	0.0954	0.103	0.110	0.117	0.123	0.130	
2000			0.0397	0.0472	0.0546	0.0619	0.0691	0.0761	0.0830	0.0898	0.0965	0.103	0.108	0.116	0.122	
2500			0.0357	0.0425	0.0493	0.0558	0.0623	0.0687	0.0750	0.0812	0.0874	0.0934	0.0993	0.105	0.111	

Wire size, Awg. or MCM	*Insulation thickness, in.*															
	18/64	19/64	20/64	21/64	22/64	23/64	24/64	25/64	26/64	27/64	28/64	29/64	30/64	31/64	32/64	33/64
14[a]																
12[a]																
10[a]	0.814	0.834	0.853	0.871	0.889	0.902	0.922									
8[a]	0.731	0.751	0.770	0.787	0.804	0.821	0.836	0.851	0.866	0.880	0.894					
6	0.608	0.626	0.643	0.660	0.676	0.696	0.706	0.734	0.734	0.746	0.760	0.773	0.786	0.797	0.809	0.820
5	0.572	0.589	0.606	0.622	0.637	0.652	0.667	0.680	0.694	0.707	0.720	0.732	0.744	0.756	0.767	0.778
4	0.535	0.551	0.568	0.583	0.598	0.613	0.625	0.640	0.653	0.666	0.678	0.690	0.703	0.714	0.725	0.736
3	0.500	0.516	0.532	0.547	0.562	0.576	0.589	0.603	0.615	0.628	0.640	0.652	0.663	0.675	0.685	0.696
2	0.466	0.482	0.497	0.512	0.526	0.540	0.553	0.565	0.578	0.590	0.602	0.613	0.625	0.635	0.646	0.656
1	0.431	0.445	0.461	0.474	0.487	0.501	0.513	0.525	0.538	0.549	0.561	0.572	0.583	0.593	0.603	0.614
0	0.399	0.414	0.428	0.441	0.454	0.466	0.479	0.491	0.502	0.514	0.525	0.535	0.546	0.556	0.566	0.576
00	0.370	0.384	0.397	0.410	0.422	0.435	0.446	0.458	0.469	0.480	0.490	0.501	0.511	0.521	0.531	0.540
000	0.342	0.355	0.367	0.380	0.392	0.403	0.414	0.425	0.436	0.447	0.457	0.467	0.476	0.486	0.495	0.504
0000	0.315	0.327	0.339	0.351	0.362	0.373	0.384	0.395	0.405	0.415	0.425	0.434	0.443	0.453	0.462	0.470
250	0.296	0.309	0.320	0.331	0.342	0.352	0.363	0.373	0.383	0.392	0.402	0.411	0.420	0.429	0.438	0.446
300	0.278	0.289	0.300	0.310	0.321	0.331	0.341	0.351	0.360	0.369	0.379	0.388	0.396	0.405	0.413	0.421
350	0.262	0.272	0.283	0.293	0.303	0.313	0.323	0.332	0.341	0.350	0.359	0.368	0.376	0.384	0.393	0.401
400	0.249	0.259	0.269	0.279	0.289	0.298	0.308	0.317	0.326	0.334	0.343	0.351	0.360	0.368	0.376	0.383
450	0.238	0.248	0.258	0.267	0.277	0.286	0.295	0.304	0.312	0.321	0.329	0.337	0.345	0.353	0.361	0.369
500	0.228	0.238	0.248	0.257	0.266	0.275	0.284	0.292	0.301	0.309	0.317	0.325	0.333	0.341	0.348	0.355
550	0.220	0.229	0.239	0.248	0.257	0.265	0.274	0.282	0.290	0.298	0.306	0.314	0.324	0.330	0.337	0.344
600	0.212	0.221	0.230	0.239	0.248	0.256	0.265	0.273	0.281	0.289	0.297	0.304	0.312	0.319	0.326	0.333
650	0.206	0.215	0.223	0.232	0.241	0.249	0.257	0.265	0.273	0.281	0.288	0.296	0.303	0.310	0.317	0.324
700	0.199	0.209	0.217	0.225	0.234	0.242	0.250	0.258	0.266	0.273	0.281	0.288	0.295	0.302	0.309	0.316
750	0.194	0.203	0.211	0.220	0.228	0.236	0.243	0.251	0.259	0.266	0.273	0.281	0.288	0.295	0.302	0.308
800	0.189	0.198	0.206	0.214	0.222	0.230	0.237	0.245	0.252	0.260	0.267	0.274	0.281	0.288	0.294	0.301
900	0.180	0.189	0.196	0.204	0.212	0.219	0.227	0.234	0.242	0.249	0.255	0.262	0.269	0.276	0.282	0.289
1000	0.173	0.181	0.189	0.196	0.203	0.211	0.218	0.225	0.232	0.239	0.245	0.252	0.259	0.265	0.271	0.278
1250	0.157	0.165	0.172	0.179	0.186	0.192	0.199	0.206	0.212	0.219	0.225	0.231	0.237	0.243	0.249	0.255
1500	0.146	0.153	0.159	0.166	0.172	0.179	0.185	0.190	0.197	0.204	0.210	0.216	0.221	0.227	0.233	0.238
1750	0.136	0.143	0.149	0.155	0.162	0.168	0.174	0.180	0.185	0.191	0.197	0.202	0.208	0.213	0.219	0.224
2000	0.128	0.135	0.141	0.145	0.153	0.159	0.164	0.170	0.176	0.181	0.187	0.192	0.197	0.202	0.207	0.213
2500	0.117	0.122	0.128	0.134	0.139	0.144	0.150	0.156	0.160	0.165	0.170	0.175	0.180	0.180	0.190	0.195

[a] Solid conductor. Conductors larger than No. 8 Awg. are stranded.

shall be not less than 46°F. by multiplying the measured value by a coefficient corresponding to the temperature at which the measurement was made. Each coil, reel, or length of wire or cable, after being subjected to the high-voltage tests specified in 4.3.1, shall have an insulation resistance in megohms per 1000 ft. at a temperature of 60°F. of not less than the value for R in the following formula:

$$R = K \log_{10} \frac{D}{d}$$

where

R = resistance in megohms per 1000 ft.
K = constant for the grade of insulation being tested
D = diameter over insulation on conductor
d = diameter under insulation

For armored cables the insulation resistance after armoring shall be not less than 80% of the value calculated by the use of the above formula.

Note: See Appendix G for table giving values of log D/d for conductors without separators. See Appendices A, B, C, D, and I covering insulation under consideration for values of K and temperature coefficients.

Where an insulated conductor is covered with an impervious sheath of a material different from the insulation, or a nonconducting separator applied between conductor and insulation so that the insulation resistance can be measured only on the completed assembly, the required insulation resistance shall be not less than 60% of that required for the primary insulation and shall be based upon the thickness of that insulation.

Note: Where two dielectrics are placed in series, as in the case of sheathed cables, or cables with a nonconducting separator, and the ratio of the capacitance and resistance of each dielectric is different, the combination will have a considerable residual charge, even though each individual dielectric may have little or none. When charging such a combination condenser, the charging current falls off very slowly so that at the end of 1 min. much more current is flowing than would be the case for either dielectric alone. Hence, the so-called insulation resistance, which is the ratio of voltage to current, after 1 min. electrification is quite low.

Section 4.1. Testing.

The insulation of all wires and cables shall be tested to determine its ability to meet the physical and electrical requirements specified.

All tests of wires and cables shall be made at the place of manufacture.

The methods described in this section are not considered completely applicable to all types of insulation, nor do they include every test applicable to a particular type. To determine the tests to be made on a particular material, reference should be made to the appendix covering the requirements for that type.

Shielding in Accordance with IPCEA Standard S-19-81—Part 5

PART 5—RECOMMENDED SHIELDING PRACTICE FOR RUBBER AND RUBBERLIKE INSULATED CABLE

Section 5.1 Specifications for Shields.

5.1.1 On multi-conductor cables when shielding is required the shield shall be applied over the individual conductors, excepting when shielding is required for reasons of safety only, in which case the shield may be applied over the conductor assembly.

5.1.2 Metallic shields should be a nonmagnetic tape, of suitable width, and at least 0.0025 in. thick. It shall be applied so as substantially to cover the surface of the insulation. If applied in an open spiral, the maximum space between successive turns shall not exceed 10% of the tape width. The shielding tape shall be substantially free from burrs, and where jointed shall be made electrically continuous by welding, soldering, or by suitable overlapping. The shielding tape should be applied directly over the insulation or fibrous tape or tapes. Metallic tapes shall be suitably protected against chemical action from contact with the insulation.

5.1.3 Nonmetallic shields may be used in some cases where safety to life is not involved, and where provisions are made to control charging current, as in power stations and substation wiring. Unless adequate metallic drainage is provided, metallic shields are most suitable where shielding is required.

Section 5.2 Recommended Shielding Practice.

5.2.1 Shielding limits given herein are three-phase operating voltages (line to line) and apply to single-conductor and multiple-conductor rubber and rubberlike insulated cables. To obtain the equivalent three-phase voltage for single-phase, or two-phase a.c. systems, or for d.c. systems, multiply the line-to-line voltage by the following factors:

Equivalent 3-Phase Voltages for Single- or Two-Phase A.C. Systems or D.C. Systems

Single-phase and two-phase a.c. systems, 5000 v. or less	*Single-phase and two-phase a.c. systems[a] over 5000 v.*			*D.C. systems, 5000 v. or less*
	One side grd.	*Mid-point grd.*	*Ungrounded*	
1	1.73	0.866	0.866	1

[a] Where it is not definitely specified that a line operates as an isolated single or two-phase system, it shall be considered as a branch of a grounded neutral three-phase circuit and the rating shall be the line-to-line voltage of this grounded neutral three-phase circuit.

5.2.2 Shielding should be considered for nonmetallic covered cables operating at a circuit voltage over 2000 v. where any of the following conditions exist:

(a) Connections to aerial lines.
(b) Transition from conducting to nonconducting conduit.
(c) Transition from moist to dry earth.
(d) In dry soil, such as in the desert.
(e) In damp conduits.
(f) Where conducting pulling compounds are used.
(g) Where surface of cable collects conducting materials, such as soot, salt, or cement deposits.
(h) Where electrostatic discharges are of low enough intensity not to damage cable but are sufficient in magnitude to interfere with radio or television reception.

5.2.3 The use of nonshielded cable may be considered for circuit voltages up to 5000 v. where the use of grounded coverings may be dangerous, or where shields cannot be adequately grounded. Examples of such installations are as follows:
(a) Pole riser cables.
(b) Connections between transformers and aerial lines on pole tops.

5.2.4 Shielding Limits.

(See Appendix M for additional information.) See Appendix M—Shielding—Section 5, Use of Shielding.

5.2.4.1 Power Cable.

Shielding is recommended for operation above the following three-phase (line-to-line) operating voltages:

Type of cable	*Single-conductor cable, kv.*		*Multiple-conductor cable, kv.*	
	Grd.	*Ungrd.*	*Grd.*	*Ungrd.*
(a) Leaded Cable	10	8	8	6
(b) Nonleaded Metallic Armored Cable	10	8	8	6

Note: Nonleaded submarine cable should be shielded at shore ends. They may be shielded throughout. Above 23 kv. grounded neutral and 17 kv. ungrounded neutral they should be shielded throughout. When subjected to a.c. test voltage after cabling, it may be desirable to supply shielding throughout to avoid the possibility of ozone cutting the insulation during test. If subjected to d.c. test voltage instead of a.c., shielding may be limited to shore ends.

(c) Fibrous Covered Cable, and Cable with Rubber Jacket	2	2	2	2

Note 1: For single- and multiple-conductor cable for installation above grade, indoors, permanently dry locations, it is recommended that shielding be used above 3 kv. on grounded and ungrounded systems.

Note 2: For single-conductor cable on full voltage insulators free from all objects, shielding is not recommended.

(d) Cable with Neoprene Jacket				
1. Above Grade, Indoors, Permanently Dry Locations	3	3	3	3
2. Underground Ducts and Conduits, Moist Location	3	3	3	3

3. Aerially on Messenger Rings or Ties	3	3	3	3
4. Preassembled or Field Spun with Metallic Binder	5	3	5	3
5. Directly in Earth	3	3	3	3

Note 1: For single-conductor cable on full voltage insulators or in air entirely free from all objects, shielding is not recommended.

Note 2: Nonshielded cable may be used for circuit voltages up to 5000 v. for pole riser cable and pole top cable where shielding is impractical or undesirable.

5.2.4.2 Single-conductor series street lighting cable.

Shielding is recommended for operation above the following open-circuit voltages:

Type of cable	*Open-circuit voltages, kv.*
(a) Leaded Cable	
1. Without protectors	10
2. With protectors	13
(b) Nonleaded Metallic Armored Cable	
1. Without protectors	6
2. With protectors	8
(c) Fibrous Covered Cable, and Cable with Rubber Jacket	
1. Without protectors	3
2. With protectors	4
(d) Cable with Neoprene Jacket	
1. Without protectors	5
2. With protectors	7

5.2.4.3 Multiple-conductor series street lighting cable.

Shielding limits to be in accordance with manufacturers' recommendations.

5.2.4.4 Portable power cable.

See Part 7, Section 7.2 (7.2.2.5—Voltage Ratings) below. For additional information see Appendix M.

Appendix M—Shielding

Section 5 Use of Shielding.

The use of shielding involves consideration of installation and operating conditions. Definite rules cannot be established on a practical basis for all cases but operating engineers and purchasers of cable should consider the following features as a working basis for the use of shielding:

1. Where there is no metallic covering or shield over the insulation, the electric field will be partly in the insulation and partly in whatever lies between the insulation and ground. The external field, if sufficiently intense, will convert atmospheric oxygen into ozone which may be destructive to rubber and rubberlike insulations and sheaths. If the surface of the cable is separated from ground by a thin layer of air and the air gap is subjected to a voltage which exceeds the dielectric strength of air, a discharge will occur causing ozone formation. The ground may be either a metallic conduit, a damp nonmetallic conduit, or a metallic binding tape or ring on an aerial cable, and at very high voltage a loose lead sheath. Likewise, damage to nonshielded cable may result when the surface of the cable is moist, or covered with soot, soapy grease, or other conducting film and the external field is partly confined by such conducting film so that the charging current is carried by the film to some spot that is grounded. The intensity of discharge may be sufficient to burn the insulation or jacket.

2. Where nonshielded, nonmetallic sheathed cables are used in underground ducts containing several circuits which must be worked on independently, the external field if sufficiently intense can cause shocks to those who handle or contact energized cable. In cases of this kind it may be advisable to use shielded cable for all voltages above 2000 v. Shielding used to reduce hazards of shock should have a resistance low enough to operate protective equipment in case of fault. In some cases, the efficiency of protective equipment may require proper size ground wires as a supplement to shielding. The same considerations apply to exposed installations where cables may be handled by personnel who may not be acquainted with the hazards involved.

PART 7, SECTION 7.2

7.2.2.5 Voltage Ratings.

Since these cables are extensively used on dredges, shovels, and in mines where service conditions are severe and where failure of the cable may result in loss of life and extensive damage to property, it is recommended that the various types of cables be limited to the following maximum circuit voltage. Cables for higher voltages are listed in Tables V, VI, VII, and VIII but are not recommended for the high rated voltages.

1. Single-Conductor, Two-Conductor Concentric, Two-Conductor Round and Flat Twin Cables	1,000 v.
2. Type W Cables	3,000 v.
3. Types G, SH-B, and SH-C Cables	5,000 v.
4. Types SH-A and SH-D Cables*	15,000 v.

* Where Maximum Safety is desired Type SH-D cables are recommended or circuit voltages over 2000 v.

Neoprene Sheath Per IPCEA Standard S-19-81—Thickness in Accordance with Paragraph 6.3.2.3 and Quality in Accordance with Appendix K.

Maximum operating temperature over 75°C. (167°F.).
AVA or ACV for dry locations.
AVL or VCL for wet locations.

DISCUSSION

MR. SILVER: On this maximum temperature over 600 v., this was not mentioned in Boston. (Concerned 70°C. copper temperature.)

MR. DAVIS: Mr. Graham, will you read applicable standards?

MR. GRAHAM: Refers to IPCEA Standards. (Reads from Standards over 600 v.)

MR. HOGAN: This (70°C.) might be classified under d.c. operation. Seems to me that problem exists in wet locations and not dry.

MR. DAVIS: Hogan is right. If you have dry, 600 v. sounds simple. What of the revised specifications? The committee took it up at the IPCEA meeting last week. Do not feel it necessary to write in all of the tables because you are referring to IPCEA Standards. If you want to write all those things in there will be a lot of repetition.

MR. MORTENSON: Will this now narrow the types down, make them less? How about sizes?

MR. DAVIS: We didn't do anything about size. We concerned ourselves only with the type of insulation, heat-resisting, moisture-resisting rubber, all sizes a.c. Alternate thermoplastic less than No. 6PVC (polyvinyl-chloride). Two types of insulation—varnished cambric and asbestos for wet locations at higher voltages. Let us presume metal covering is being replaced by neoprene sheath, then we are cut down to four or five types of insulation.

MR. ZINK: One thing we might classify. We are assuming that we are considering a wiring program for the plant. However, for an office building construction code wire is okay. We have not covered that. You are worried about the manufacturing departments of the plant. A simple, straight, ordinary office building we have not covered.

MR. MORTENSON: No, we are not considering office buildings. Mr. Andrews!

MR. ANDREWS (commenting on Mr. Davis' statement above): Conditions are different in this country. Your policy is freer to consider them as different types of insulation.

MR. DAVIS: Rubber is short but not near as short as copper.

MR. ROSCH: PVC apparently is not short. It is now being made in the United States by Bakelite, U. S. Rubber, Firestone. Boys checking from maintenance angle can get plenty. It is whether you want $^{2}/_{64}$ or $^{3}/_{64}$ in. Can use your judgment. It isn't the only material available.

MR. ANDREWS: You can use others, we feel, up to 5000 v. We are considering the paper industry as a whole. These are long-term specifications.

MR. DAVIS: Manufacturers' specifications, later on when they come out, could be inserted.

MR. ROSCH: Add that both ASTM as well as IPCEA are preparing those specifications. Mr. Davis said manufacturers.

MR. GRAHAM: The types Mr. Davis mentioned above are not special. They are typical. All manufacturers should be able to make them. It is not a special construction.

MR. MORTENSON: What we had hoped to do and prepare, this does not do. We had hoped to give the boys in our industry something simple that they could tie to with certainty that they were getting the very best that the market afforded for every job, every department in every branch. Does what Mr. Davis suggests do this?

MR. DAVIS: We feel that it does.

MR. ROSCH: Not only that but the PVC we specified made much of the fact that we wanted $^{3}/_{64}$ in. to be sure that for the paper industry nothing but the best would be made available.

MR. DAVIS: Only high quality figured. Underwriters for dry location refer to IPCEA—without going into detail.

MR. ROSCH: Don't let the simplicity fool you, Mr. Mortenson. We have made this into a simple form. But, we had a very bitter discussion until we came to an agreement. Every point, step by step, was contested in Boston. We all feel the same way.

MR. DAVIS: These recommendations can be made into a booklet, including the tables, to become TAPPI specs. Reference to IPCEA Standards might give the TAPPI Specifications a certain prestige that would be helpful.

MR. MORTENSON: That might be, but it still means that an engineer in our industry confronted with a wiring program would be obliged to thumb through a lot of literature to determine what a particular spec called for and that is just what we are seeking to avoid.

MR. ROSCH: There is one advantage doing it our way. You do not repeat these items but merely refer to the latest edition of our Standards. In other words, it would never be necessary for you to reprint very much from our Standards.

MR. MORTENSON: Let's take a case. Assume that recovery room expansion was being considered in the sulphate industry, how would we apply just what we have been given to that problem?

MR. ROSCH: What voltage?

MR. MORTENSON: 600 to 2400.

MR. ROSCH: 600 wet location and hot. Hotter than 75°C.?

MR. MORTENSON: Yes, in sections.

MR. ROSCH: Go to section, Max. Operating Temperature over 75°C. We have AVA or ACV for dry locations; AVL or VCL for wet locations, 600 v. or over. Mr. Davis, do you have another copy of our recommendations that I can have?

MR. DAVIS: No, but I will send you one. I came away this morning with but a few second sheets. Have plenty of firsts but no seconds. Here's one.

MR. ZINK: You feel, Mr. Mortenson, that you would want to take each location separately and put a reference to each location?

MR. MORTENSON: Yes, so that in considering a wire for any service, in any department of any branch of the pulp and paper industry a reference to a chart or a table could be made and a TAPPI Spec. number so and so could be selected.

MR. ZINK: That can be done by setting up a key and fitting it into departments. (Mr. Davis leaves the meeting to get copies of the recommendation typed up. Brief recess—returns.)

MR. ANDREWS: Lead is hard to get. Allocation of lead is soon to take place, I think.

MR. DAVIS: We have varnished cambric, nonleaded, in service but not in wet locations. Neoprene or rubber sheath are not impervious to moisture. The only thing impervious to moisture is a metal.

MR. ZINK: May be using a lot of aluminum a year from now.

MR. MORTENSON: While waiting for the secretary to bring us Mr. Davis' typed-up copies of his report wonder if we could take a look at this report.

(Mr. Mortenson holds up report submitted by himself to the Savannah Conference.)

First, let's consider this first chart which is application of electric cable as gleaned from returns of the questionnaire across the board. Let's note that in the sulphate industry (the red line shows first preference—Sulphate goes for natural rubber neoprene sheathed; Sulphite, natural rubber braided; Groundwood, thermoplastic; Wastepaper, natural rubber braided; Rags, same thing; and Others, same thing. With that before us, does what we have been given this morning adequately cover?

MR. DAVIS: We think it does. We don't think, though, that braid is a proper cover. It rots and disintegrates. You know how it is if you have ever pulled any out of a pipe. Now as far as natural rubber is concerned, up to 1942–45 most cables were natural rubber. Now you have synthetic. Better than natural. Some people say natural rubber but get synthetic. So when you say rubber you are getting rubber of one sort or another. More manufacturers could and would produce natural rubber insulation on a stock basis if required. If a particular manufacturer supplied synthetic—okay. The result would be the same.

MR. EYTON: We should not differentiate between the two. Noting the point you raised—doing away with braided cover, if agreeable throughout the industry, we should do without it. It does rot. It does disintegrate after some years in operation.

MR. MORTENSON: That's true. Neoprene sheath is the better.

MR. DAVIS: To pull out and reinstall creates one big mess. It gets destroyed during shipment. Then if you take out a line here to use elsewhere the braid is rotted and can't be used.

MR. ANDREWS: Usually the rubber has gone too.

MR. DAVIS: Don't think a neoprene jacket adds to the comparable cost of cable. That is another point in doing away with the braided covering.

MR. ZINK: You are right, Ernest.

MR. DAVIS: Our program should be to eliminate braid.

MR. EYTON: About drawing up some sort of standards—as far as our company is concerned I think what they need is a general specification for each department. From the woodyard go straight through the specific conditions encountered in each department and then determine types of cable to be recommended including for motors, motor control, lighting, etc., which would state the type of cable. D.c. should not make any difference. We have had no difficulty with d.c. wiring.

MR. MORTENSON: That was what we were hoping to accomplish—the very thing you have mentioned, Mr. Eyton.

MR. EYTON: From the mill standpoint!

MR. ROSCH: I think that if we still go along on the basis recommended we can settle on 600-v. service in dry locations; wet too. We have a series of recommendations. These may be classified up to and over 75°C. These are basic facts. Then from that point on we can set up classifications in each one of those rooms.

MR. ZINK: So that your plant operating men will know where they are. We can make a summary.

MR. DAVIS: This is simple. All we say is wet, dry, below, and over 75°C.

MR. EYTON: We should consider the chemical departments.

MR. DAVIS: Many of us took those lists of chemicals encountered as contained in the minutes of the first and second meetings to our chemical lab. They advised that neoprene was okay for it all.

MR. MORTENSON: Refer, please, to our second meeting. See what we have in chemicals. Are there any other chemicals, Mr. Eyton? You will have to take time to look this over.

MR. ANDREWS: Perhaps I have time to make this remark. So much depends on the way these things are compounded. They can do so many things with it, it just means specifications so cable manufacturers can go to work on it. In all these things that can be compounded to meet certain conditions, that should be left with cable manufacturers. And certain resistance to various types of corrosion, I don't know how far general specifications could go.

MR. MORTENSON: Makes me wonder also. Seems to manifest the need for special specifications to cover each condition.

MR. ROSCH: I want to differ with Mr. Andrews. It is generally understood that you can pick a specific condition that will be more or less common to another condition yet both producing different characteristics. Any manufacturer would be foolish to produce something that would be a bother to his customer. We know all compounds are not the same. Each one is designed for a special purpose and would not be used in a place for which it was not designed. Getting down to basic installations and voltage classifications of cables you could not use general specifications. For instance, moisture-laden locations with various types of chemicals. We would have to know that a certain type of cable is okay.

MR. GRAHAM: As to neoprene sheath, the prime reason for using it is to obtain mechanical protection during installation and be resistant to chemicals.

MR. ROSCH: Might add a few more things. Neoprene is flame retardant too as well as being resistant to chemicals. It is preferable to use as a sheath instead of braids. As such, it is acceptable to the Navy and the Underwriters'. It will necessitate us treating this (the pulp and paper industry) as an ordinary chemical plant. That could be put in the preamble to your specifications. And when we are covering moist locations then I think that we should put down a warning.

MR. DAVIS: If you do too much warning you will cause confusion.

MR. ROSCH: Well, then, just give due notice.

MR. GRAHAM: Another thing, think how these cables are installed—conduit, trays, open wire, etc. The recommendations we have made do not change that.

MR. SMITH: Would that be for aerial outside installation, G.E. interlocked, armored cable, self supporting?

MR. DAVIS: Yes.

MR. ANDREWS: How is bus duct finding its way into the industry?

MR. MORTENSON: It is getting a place but not predominantly used.

MR. ANDREWS: Cable is still the preferred means.

MR. MORTENSON: That's right.

MR. ANDREWS: Bus duct has come into great favor now because of its flexibility.

MR. ROSCH: Bus duct is being used where machine tools are being used.

MR. GRAHAM: Analysis of the questionnaire across the board lists bus duct at $1^1/_2\%$ of all the other things used.

MR. MORTENSON: Find that so, do you not, John?

MR. EYTON: Use it very little.

MR. ROSCH: I might say that the only thing we have omitted is the new type of cable by General Cable. That is the MI cable for 600 v. service at 75°C. operating temperature. We should include that.

MR. DAVIS: It is no industry standard. It's a one-company product. If a manufacturer can sell it, okay.

MR. EYTON (addressing Mr. McGrath): We will have your company in the East turning it out for Canada.

MR. DAVIS: Still not able to give it to you as an industry standard.

MR. EYTON: I think so. Lots of paper people are looking for high-temperature cables. For instance, for lighting and controls, pyrotenex. It is a very, very rugged conductor.

MR. MCGRATH: Mr. Warr is in charge of our MI cable department and is best qualified to describe the cable. Will you do so, Mr. Warr?

MR. WARR: MI in this country is solid copper conductor insulated and encased in a copper tube. The cable is for 600-v. operation. It will operate under conditions of 250°C. and is completely moisture sealed. Although we have not made any study of the paper industry we feel that it might have applications there. We would like it to be known that such a product is available.

MR. MORTENSON: The paper industry will thank you for that information.

MR. EYTON: I have spoken to fellow manufacturers in Canada and they would recommend the same type of cable. It is really needed in our industry.

MR. ANDREWS: My feeling is that it should be demanded outright. Certain things are accomplished in doing that. But maybe I am a little prejudiced because of my regard for an aluminum sheath.

MR. MORTENSON: Is this type of cable so special that all manufacturers cannot manufacture it?

MR. ROSCH: That is right.

MR. GRAHAM: Mr. Warr, would it be available with other metals?

MR. WARR: Other metals, not in near future.

MR. SMITH: Up to now we have not discussed aluminum conductor. Will these specifications that we have set up now be satisfactory and the same for aluminum conductors?

MR. DAVIS: Yes, they will be the same but larger structurally. Two sizes larger, as far as we know now. We are trying to set up tables. The characteristics are essentially the same. Probably will be available in six months.

MR. SMITH: The point of my bringing it up is due to the probable future copper shortage. We might be forced to aluminum.

MR. DAVIS: Some manufacturers have done more than others in this respect. It is not the practice of one manufacturer. We are not in a position at this minute to make those specifications.

MR. ZINK: As a matter of advice, Mr. Smith, if we are going in for aluminum conductor be careful. Certain things that you would have to take precaution of—chemical fumes in your plant. Don't try to use ordinary copper connectors. It requires special connectors—a full line of which have not yet been developed.

MR. DAVIS: Based on experience of other manufacturers no example exists that says it cannot be done either way.

MR. SMITH: Those are things I wanted to bring out.

(Mr. Davis' typed up reports are brought in.)

MR. MORTENSON: I am going to ask you, Mr. Davis, to pass these papers out. Now that we all have a copy of the recommendations, even though they have been read into the record already, let's go over them again.

(The recommendations were then reread by Mr. Davis while the other committeemen followed from their typed copies.)

MR. DAVIS: In submitting the final report the references to IPCEA Standards can be copied.

MR. ZINK: I don't know, Mr. Mortenson, but you seem unhappy about these recommendations. Has it anything to do with sticking to IPCEA references?

MR. MORTENSON: I am not able to judge. Based on the recommendations as presently set up, completeness as we expected is not in evidence.

MR. ROSCH: IPCEA is recognized. I feel along with Zink that you feel, Mr. Mortenson, that it does not go along in each particular room. I can see a simpler way of doing it.

If we took each room, classified as a type, tied in with these recommendations it would be the same thing as we recommend.

Mr. Davis: Nearly all rooms carry one type of cable. What we want to add in your specifications can be typed in right out of these IPCEA Standards that are already published.

Mr. Smith: Tie the type of cable together with the room.

Mr. Rosch: These Standards are available in Canada.

Mr. Andrews: Perhaps after this discussion, which is very good, we can take this room by room. We should then have something that will do the job, I think.

Mr. Davis: I think we can do it very fast.

Mr. Rosch: I don't think so.

Mr. Silver: In Boston we went through each room. Same type of cable. Same answer for each room.

Mr. Rosch: Let's take a few rooms and then you will see for yourself, Mr. Mortenson, particularly how it centers down to the same type. Mr. Silver, you read.

Mr. Mortenson: Page 31 of the Savannah report as an example. No, that isn't the one. Can you, Mr. Silver, give us the types? Have Mr. Andrews and Mr. Eyton a copy of this? (Chemicals and Conditions Encountered in a Typical Southern Sulphate Pulp and Paper Mill.)

Mr. Andrews: We can both look at this one.

(Refer Exhibit No. 1, pages 4, 5, 6 of these minutes.)

Mr. Silver: Chip preparation room, rubber neoprene and rubber braid. Did not differentiate between natural and synthetic rubber. All right, wood room, rubber neoprene and rubber braid; digester room, rubber neoprene, rubber braided, thermoplastic; brown stock wash room, rubber braid, rubber neoprene, thermoplastic; jordan room, rubber braid, rubber neoprene, thermoplastic; finishing room, rubber neoprene, thermoplastic; caustic plant, varnished cambric and braid, rubber neoprene and rubber braid; evaporator room, thermoplastic, rubber neoprene, rubber braid; machine shop, indoor conditions; boiler room, rubber neoprene, rubber braid, asbestos varnished cambric; lime kiln, rubber braid, rubber neoprene; salt cake storage, AVC. Actually if we scan through the different rooms we find that the same type of cable covers all the rooms.

Mr. Eyton: Is that necessarily the best?

Mr. Silver: Considering the reasons for failure we believe these recommendations would solve the problem.

Mr. Rosch: PVC used in heavier thicknesses.

Mr. Silver: The failures that were detected may have been caused by the aged condition of the rubber.

Mr. Andrews: Am wondering if there is any really sound basis for saying that the rubber was the cause of failure? We use 75°C. rubber.

Mr. Davis: Not at present.

Mr. Zink: Heat-resisting rubber will not cost you any more money.

Mr. Rosch: To answer your question more specifically, Mr. Andrews—in many factories we have seconds—cable at 75°C.—with water present. Now the only type of cable to use is the 75°C. rubber moisture resisting, designed for overload.

Mr. Andrews: Just want to get my thinking the same as yours.

Mr. Rosch: Does that agree with your thinking?

Mr. Andrews: Yes. Now, in the recommendations, has voltage been taken into consideration?

Mr. Rosch: Yes.

Mr. Davis: All 600 v. or less and next over 600 v.

Mr. Andrews: Suppose you go up to 15 kv.—would you use paper insulation?

Mr. Davis: Very little paper, but paper should be mentioned.

Mr. Eyton: We use paper entirely at that voltage. We recommend paper with a protective sheath.

Mr. Graham: We are trying to consider lead.

Mr. Davis: Above 600-v. paper and lead.

Mr. Rosch: Might I ask, do you think in general most of the paper mills would have electricians who know how to make joints in paper and lead cable?

Mr. Eyton: Yes, there's one man in each outfit who can do it.

Mr. Zink: You should hesitate to use paper unless you have people who can handle it. If you do it is okay.

Mr. Graham: I notice as a result of the questionnaire that only 2.4% of the sulphite branch used paper insulated cable.

Mr. Rosch: Out of 300 replies to the questionnaire we were surprised to see how little paper was used in the entire industry.

Mr. Eyton: Not as far as we are concerned. (In Canada.)

Mr. Graham: I suppose it is a lack of experience. It's a new thing for them.

Mr. Rosch: I feel the same as you do, Mr. Eyton. There's nothing like paper cable. But certainly you would not recommend the lead sheath be unprotected.

Mr. Andrews: This brings up another point. Have paints been used in your pulp and paper mills?

Mr. Hogan: If it is hung up on racks in the mills and you have a good paint, you can paint the cable. Perhaps that should come into our thinking along with neoprene, etc., as a protective coating for lead.

Mr. Zink: Canada seems to be following European practices in this respect.

Mr. Graham: How much 15,000 v. is used in the paper industry?

Mr. Zink: A whole lot. It's a general trend now for generation and prime feeders.

Mr. Hogan: Lead sheath is sometimes reinforced with a neoprene covering over the lead. But, there has not been enough sold in this country to have warranted much investigation. Perhaps on 15,000 v. but not so many. Has been principally for underground and for weather purposes.

Mr. Graham: It is extensively used in chemical plants.

Mr. Andrews: Well, you can hang it up and paint every couple of years.

Mr. Rosch: What would you do underground?

Mr. Eyton: If you have to go underneath in some places armored neoprene would be good.

Mr. Rosch: Going along with paper cable, I still say that a majority of electricians would not be familiar on how to install paper cable.

Mr. Andrews: As long as you have a chance and take proper care of such cable it is all right.

Mr. Rosch: We were guided by the vast number of replies to the questionnaire. There was very little paper cable used.

Mr. Davis: Seems to me that the cable recommended up to 5000 v. with a neoprene sheath is better than paper. Especially in view of the lack of skill of installation. Above 5000-v. paper and lead or varnished cambric. We are telling a fellow here what he ought to buy and we ought not to do it (IPCEA).

Mr. Eyton: We would have to specify voltage.

Mr. Zink: I am very much interested in what Mr. Eyton has had to say. There is considerable difficulty in getting various ones to use paper. People in this country seem to be frightened of it.

Mr. Graham: Aren't we getting into too many types? We should have as few adequate types as possible. Otherwise, we will defeat our purpose.

Mr. Davis: We go along with rubber neoprene up to 6600 v.

Mr. Hogan: That's all right but you could use paper-insulated cable for 6600 or 15,000 v. because it is cheap.

Mr. Eyton: It is a better cable, not only cheap.

Mr. Hogan: But don't forget there is a splicing and installing problem. Varnished cambric is not as susceptible to moisture.

Mr. Rosch: In this country 15,000-v. cable is mostly neoprene and rubber. It is an important thing to use paper cable, but they will not use it. Only rubber and neoprene jacket. They still go for rubber except the utilities who know how to handle the other insulations.

Mr. Andrews: It is hard to argue against experience. We should discuss these things. We cannot afford to neglect them.

Mr. Rosch: I agree that over 5000-v. paper-insulated cable should go in as an alternate.

Mr. McKinley: Bearing in mind that over 75°C. we have two types with lead—AVL and VCL, shouldn't we put something in there to protect the lead?

Mr. Rosch: We have mentioned that we should protect the lead sheath by various means. Can we decide here whether we want to include paper over 600 v. working pressure?

Mr. Mortenson: Yes, would say yes, and can we get an expression?

Mr. Rosch: I am for it over 5 kv.

Mr. Hogan: 6600 is an old style system. It is still good and remains from the old days.

Mr. Davis: We should have two voltage ranges over 600—600 to 5000 and another 5001 and over.

Mr. Graham: We now have all types of cable for 5000.

Mr. Davis: We can put them in order of preference. I thought we only wanted a certain number of specifications in a particular group, so we could easily select a spec and it would state what should be bought, and not have too many different types.

Mr. Zink: Is there any objection to giving alternates?

Mr. Graham: Include the alternate which is best. One must be better than another. If you give too many different recommendations you will be back where you started. Point is to confine this thing to a minimum.

Mr. Zink: I don't know. In choosing a cable it is the same as in choosing a wife—which one is best.

Mr. Graham: We now have four types for over 5000.

Mr. Smith: We should have a limited number of TAPPI Standards backed up by IPCEA based on the results from the questionnaire. For most of the services I would like to be able to specify a TAPPI Standard backed up by IPCEA's considered opinion in relation to all of the information we have obtained from the mills.

Mr. Davis: Certainly can't have that and have a lot of alternates.

Mr. Smith: The purpose of the whole thing is to limit the number of types of cable so that Plant Engineers and electricians could refer to the TAPPI Standards and be safe in what they select. They would see that the TAPPI Standards were backed up by the IPCEA Standards for the specific application. In other words, suppose we were to expand a recovery building. All that we would need to do would be to take off the required quantity and sizes of cable required then specify that the cable should meet the appropriate TAPPI Standard and IPCEA Standard. Do you agree with that, Mr. Mortenson?

Mr. Mortenson: What has been proposed up to now is something rather difficult to handle. But, if it could be done just as Smitty has now outlined it would be relatively simple.

Mr. Graham: Of course Smitty has to have an alternate. What would you take, Smitty?

Mr. Smith: Nowadays, I would take what I could get, the best alternate recommended.

Mr. Zink: You will always have that as long as we have salesmen.

Mr. Smith: What is the significance of the code requirement that you stress cone shielded cable?

Mr. McGrath: It is a matter of electrical stress, Mr. Smith. If in a shielded cable, the factory applied shielding is merely removed for a certain distance from the end of the cable and terminated abruptly there is a very uneven distribution of voltage on the surface of the exposed insulation and there exists at the terminated edge of the shielding tape a region of high electrical stress. Under certain conditions this concentration of stress may be sufficient to produce streamer, corona, or similar type of discharge at the edge of the shielding tape resulting in time in deterioration or even failure of the cable insulation in this region. In order to avoid this type of action it is the accepted practice on shielded cable to build up, by the hand application of insulating tape, a gradual increase in the insulation thickness at the edge of the shielding tape in such a manner as to form a cone or taper of suitable dimensions. The surface of this hand applied cone of insulation is metallized by applying copper tinsel braid or composition foil to conform snugly to the shape of the cone. The application of the braid or foil is carried to the point where the diameter of the cone is a maximum. At the base of the cone the metal braid or foil is soldered to the factory applied shielding. By use of the stress cone the factory applied shielding, in place of being terminated abruptly, is in effect enlarged or expanded gradually with a consequent reduction in the concentration of electrical stress and the effects thereof on the cable insulation.

Mr. Graham: I'm glad you brought that up, Smitty. The Underwriters' recommendation specifically covers nonleaded fibrous and rubber-insulated conductors. Does the paper industry have to stick to code requirements?

Mr. Smith: We meet it or better it.

Mr. Hogan: Requirement of the National code does not apply to neoprene sheathed cable.

Mr. Zink: I think Mr. Hogan is right, but the code is wrong.

Mr. Hogan: The code says nonlead fibrous cables.

Mr. Davis: Let's get something done. Supposing we set 600 to 5000 as recommended and over 5001 go to paper and lead as an alternate. We all agree that at 15,000 v. paper and lead are most economical to use. Can argue that for new long lines at 15 kv. paper and lead would show the lower cost. However, on short runs the chances are that paper and lead are uneconomical. Let's make a definite recommendation without a lot of alternates.

Mr. Mortenson: 5001 and over?

Mr. Rosch: Yes. On voltages over 5 kv. there is a question as to what you want to recommend. But, we should leave the recommendations as they stand up to 5 kv.

Mr. Davis: Per TAPPI Standard. One recommendation for each classification.

Mr. Hogan: For short runs paper and lead will not be economical at 5 kv. On short runs there is the cost of two potheads to consider and the cost of putting them on.

Mr. McKinley: You must take into consideration and account that personnel will be involved. Paper is better electrically but it must be kept completely dry. Paper will give trouble if wet. It all comes back to the matter of personnel that does the job.

Mr. Smith: That's right.

Mr. Davis: We should not have more than one prime recommendation in each classification; but, we still should have an alternate.

Mr. McKinley: What is the IQ of the personnel handling the cable? Would these be contractor jobs or would they be done by mill personnel?

Mr. Smith: Could be done both ways. I represent a contractor personally. The capability of the personnel is probably the reason why more paper is not used.

Mr. Mortenson: What is your experience, Mr. Eyton?

Mr. Eyton: One reason why you did not get more replies

concerning high-voltage cable is that very little is presently used in the mills. Most of the distribution is at lower voltage.

MR. MORTENSON: What should the recommendations be for over 5 kv.?

MR. ROSCH: I would suggest that you have classification 601 v. up to 5 kv. which would come under (g) just as it is. Then under (h) have another classification for 5001 and over. Let the first three parts, 1, 2, and 3 be the same as under (g) and let 4 (alternate) become Paper Insulated Cable with protected sheath.

MR. EYTON: What about protecting the sheath that is usually run on larger motors. Why should we protect the lead covered sheath?

MR. DAVIS: Because it is exposed to fumes and chemicals.

MR. EYTON: That might be all right as a footnote.

MR. ROSCH: I call steel armored type a protected cable.

MR. EYTON: For underground and overhead service!

MR. ROSCH: I would say a protected type is required. In your industry any insulation having a lead sheath should not be without protection over the lead sheath.

MR. MORTENSON: In certain departments of the mill that would be all right.

MR. ROSCH: Remember at the outset we considered paper mills as chemical industries. Your lead should be protected.

MR. EYTON: I think perhaps, Mr. Chairman, we do not run up against many fumes in our mill—newsprint—groundwood.

Mr. MORTENSON: That's right, it would be mostly water.

MR. GRAHAM: Sam, that of course is when you talk about paper cable.

MR. MORTENSON: Let me ask those of you representing cable manufacturers if we can boil this down to a standard specification for each department. Can that be done?

MR. DAVIS: Yes. What we have given you takes care of them all.

MR. MORTENSON: This may cover all right, but it is altogether too general and complicated. My thought is to set up standards so that people in the industry can merely refer to a set of TAPPI Standards in making their selections of wire and cable, just as Smitty outlined a short time ago.

MR. ROSCH: You would require a set of specifications for PVC 600 v., one for paper cable, one for rubber up to 600 v., one for rubber over 600 v., and several others—five or six complete specifications. They would be complete specifications in themselves. Then you would not have any reference to IPCEA, etc. Then you would have to go to each room for the type specification recommended or its alternate. We thought that would be bulky. Besides specifications change. This would be a danger. Your members would not have the latest revision of those specifications. Do it the way we did and just refer to each one as a class—class 1, class 2, etc.—then have a key showing what rooms the classes apply to.

MR. DAVIS: One applies to all the rooms, all classes.

MR. ROSCH: I agree, but Mr. Mortenson wants it more explicit.

MR. MORTENSON: It seems to me that what you have given us or recommended leaves us just where we started.

MR. GRAHAM: In preparing your five and six sets of complete specifications, not only the present standards but any revision will affect these specifications.

MR. ROSCH: You will still have to label those Nos. 1, 2, 3, 4, etc. Isn't that what you want, Mr. Mortenson?

MR. MORTENSON: That's the idea.

MR. EYTON: We seemed to have missed out on the method of installation. Haven't discussed it today.

MR. ROSCH: Mr. Eyton, in the minutes of the second meeting there was quite a bit of discussion regarding the method of installation, quite a discussion. You are correct, the nature of the installation means a whole lot.

MR. DAVIS: Take what Sam suggested, six or seven types of cable—each type, each room—would that be satisfactory, Mr. Mortenson?

MR. MORTENSON: Well, I am a little bit hazy on it. I really don't know. I can only say that we had hoped to simplify the matter of making selections a lot. Whether this does it I don't know. I'm somewhat confused, really.

MR. SMITH: I think the thing to do is to set up a key form so that these recommendations can be used. Simplifying it to two or three types of cable and operating voltages, and tie it to the various rooms.

MR. DAVIS: Look under 2(c)

MR. MORTENSON: Mr. Eyton made some suggestions in writing to me on July 20. I'll read what are to me the paramount suggestions.

(Mr. Mortenson reads.)

"Note: Suggest minimum number of cable sizes be used and paralleling where necessary to get the required current carrying capacity.

"The above only briefly explains our views regarding desired reference from the data being collected. It would be to the advantage of the industry if we could cut to a minimum the multitudes of cable sizes and types that we have to choose from."

Does this do it?

MR. ROSCH: 100%.

MR. MORTENSON: That's all we are striving for.

MR. DAVIS: Maybe if we set it up some other way it will appeal to you more.

MR. ROSCH: When a paper mill electrician wants to purchase a class of material to a certain specification you want him to have a guide that will be simple yet complete.

MR. MORTENSON: That's right. Seems to be about it. And, now, perhaps we can bring this to a close very quickly.

MR. DAVIS: What will we do with paper and lead?

MR. ROSCH: That is taken care of under the 5001 v. and over recommendation we have added. Paper-insulated cable with protected sheath is recommended as the alternate.

MR. GRAHAM: There is good reason for having individual specifications. Supposing a man is buying 600-v. rubber with neoprene sheath, how is he to describe it without specifications?

MR. ROSCH: Going back to our recommendation we would have item 2(c), class 2, complete spec.; or type No. 2, somehow or other it will have to be a class.

MR. ANDREWS: Could we, under those classes, list certain rooms in the plant? Conditions may be different in different plants. Could you say that the wood room is definitely class 2 or 3?

MR. ROSCH: I am not an encyclopedia on paper mills. It is my understanding that you could.

MR. EYTON: Yes, you can.

MR. MORTENSON: Think that's right.

MR. GRAHAM: Would you gentlemen, in setting up these classes, limit the scope regardless of any conditions?

MR. ROSCH: I wanted it simpler than that. A fellow would look through the sulphite branch and say, class 3.

MR. MORTENSON: Mr. Eyton, is that your idea?

MR. EYTON: Yes, I think it is all right.

MR. DAVIS: What classes of insulation would be involved?

MR. EYTON: Do believe that d.c. classes should be taken out.

MR. ROSCH: You know I am really surprised to hear you say that. We have heard of many troubles on d.c. We thought we were doing the industry a favor by including it in our recommendation.

MR. EYTON: Mr. Chairman, have you had any difficulty with d.c.?

MR. MORTENSON: No, not any great amount of difficulty.

MR. ANDREWS: Same thickness insulation, d.c. and a.c.?

MR. ROSCH: If there are no difficulties we should take the same thickness for each.

Mr. Hogan: Earlier we said 1000 v. insulation on a.c., would that apply to d.c.?

Mr. Eyton: Not all mills go to 1000 v. Some do, others don't.

Mr. Hogan: One thing, don't they sometimes use a heavier thickness of insulation?

Mr. Eyton: I am for 1000-v. insulation on all. On low tension mill systems you should use a higher insulation—especially rubber insulation.

Mr. Hogan: Why not 2300-v. insulation in all 600 classifications—a.c. or d.c.?

Mr. Eyton: Well, over 1000 v. I'd say just a heavy 2000-v. insulation.

Mr. Zink: I agree with Mr. Eyton.

Mr. Smith: Could we not go on record for using 600-v. insulation on 600-v. d.c. systems and just add a thickness of insulation as a matter of insurance. Seems that this would be safe and more economical than 1000- or 2000-v. insulation.

Mr. Graham: How about d.c. in submarine locations?

Mr. Davis: We have most trouble with d.c. control cable in this country. D.C. cables for power service do not give very much trouble. Power cable as a rule especially No. 6 or No. 4 should have $^{1}/_{64}$ or $^{2}/_{64}$-in. heavier wall thickness to start with.

Mr. Graham: Going back to the statement Mr. Eyton made—concerning the susceptibility of ground hazards on Delta systems when using 600-v. insulation for which he recommended 1000-v. insulation. That was for a.c. What we are talking about now is d.c.

Mr. Davis: Mr. Eyton, your experience indicates we need not cover d.c. as a separate class.

Mr. Hogan: Regarding 600-v. walls of insulation there must be some discharge through it to attract a ground which would occur with old insulation.

Mr. Eyton: Yes, in the weak spots you get a good shock.

Mr. Graham: Yes, that's true, but now we are trying to recommend newer insulation.

Mr. Rosch: Mr. Mortenson, I can see from your face that you are not satisfied in your mind. I think I understand what you want. Best thing for us to do is to prepare specifications for each type of cable. We cannot do it at this meeting. It would take too much time. I am trying to see what is most satisfactory to you.

Dr. Sturdevant: What are more detailed specifications?

Mr. Mortenson: Classifying the types of cable with the rooms.

Dr. Sturdevant: If you do that we would simply have a repetition of the various recommendations we have given you. If we assume that our recommendations are satisfactory let's call 600-v. cable No. 1 under "C" with copper up to 60°C. and over 75°C. Under 60°C. it is No. 1 and No. 2—No. 2 being thermoplastic. D.C. would be No. 3 and over 600-v. No. 4 or No. 5, which are ozone-resistant rubber or its alternate, polyethylene. Those classifications will go throughout your whole group of rooms. What does that contribute?

Mr. Mortenson: Sounds all right, but I don't know. I'd like to study it further.

Mr. Rosch: Which room is a wet location and which is dry? Originally what we hoped was that the individual would decide that for himself. According to what Mr. Mortenson indicates we require a type spec. for each room. How are we to set up these classifications? Can we accept these that we have as doing that job?

Mr. Davis: There will be a lot of repetition if we do.

Mr. Smith: An electrical engineer, or an electrician in the industry would want to see the IPCEA specification. I, for one, would not be content just to see a specification as a number. I would want to see the written IPCEA specification to back it up.

Mr. Davis: Let's see the IPCEA Book of Standards.

Mr. Hogan: Let's get an outline of what we would propose under class rubber neoprene, for instance, and establish a table of sizes, etc.

(Mr. Davis reads from IPCEA General Specifications, Second Edition, February, 1951, Standard S-19-81.)

Mr. Davis: We could have a footnote that for conductor sizes, thicknesses, and all test references refer to IPCEA.

Mr. Rosch: Mr. Hogan, certainly that could not be done today.

Mr. Hogan: The design of an installation has to be worked out from those thicknesses. Impossible for a designer or an electrician planning a job to work it all out intelligently without the proper statistical data, such as insulation and jacket thicknesses.

Mr. Andrews: What do you think, Mr. Mortenson, should we have a special standard for any special case? If we could tie it down to this, it would do two things. It would give the individual confidence, help cable manufacturers, and the guesswork would be taken out.

Mr. Mortenson: I agree with you entirely. That's the room-by-room proposition that we want.

Mr. Davis: As Mr. Hogan says it is important to know thicknesses.

Mr. Mortenson: Let me see how much would have to be copied from your IPCEA Standards to give us what we want. Bob, will you be good enough to go through the book and mark the pages and show me. You're more familiar with the book than I am.

Mr. Hogan: Areas in these tables do not give you too good of an idea. It's no trouble for a cable manufacturer to look at a table and get the thickness of a sheath but it might be a little confusing as it stands to outsiders.

Mr. Davis: Shall we cover all sizes?

Mr. Hogan: Let's include only the most important standards so we would not have to cover everything that IPCEA does.

Mr. Davis: It will come out plenty bulky at that. Let's write up everything and see what they want cut out.

Mr. Rosch: As to the question of paralleling of conductors raised by Mr. Eyton. We cannot do that as cable manufacturers. I want to get down to as few types as possible. Question of sizes. No one can tell us what size to use except you paper people. Paralleling of conductors is strictly up to you. It is ridiculous for us to touch it, as manufacturers. Do you really feel that we ought to include sizes? We already have a number of things that do not appear in the specifications.

Mr. Davis: There are certain in-between sizes that cannot be set aside. When we get through with the specifications we are now going to write there will be nothing we can add. That will be up to you.

Mr. Rosch: The code definitely outlines the requirements for paralleling conductors.

Mr. Eyton: Nevertheless, paralleling is a good point to bring up to the industry.

Mr. Graham: Mr. Mortenson, it would require, out of this book, about 14 pages, not including the tests. Might be some repetition. Good part of 3 or 4 pages on how to make an ozone test. That's a lot of copy work.

Mr. McGrath: As to parallel users, do they line up on what they call their own specifications or refer in general to these specifications as to insulation thicknesses, etc. It might be possible to check out a few voltages and set up 3 or 4 tables to completely specify the construction to which the industry (TAPPI) specifications refer.

Mr. Rosch: Can't do that today.

Mr. McGrath: No, we can't do it today. How do you propose to do those things just referred to?

Mr. Davis: Mr. Mortenson, with all these tables just referred to would that be all the specific information you would need so that your engineer could see what he was getting?

Mr. Mortenson: I believe it would, Mr. Davis. I can't say for sure without some time for study.

Mr. Davis: In order to do that, suppose TAPPI were to

set up standards, at say 3000, 5000, 7500, 15,000 v. and prepare tables with the wall and the jacket thicknesses and do the same with d.c.; that is, tables showing dimensions—would that not tell you all an engineer would need to know?

MR. MORTENSON: It seems that that would cover the situation. You did not mention 600 v.

MR. HOGAN: Such tables would be useful in determining the sizes of conduit and other raceways. Where everything is in terms of over-all diameters it is easy to see what size of conduit should be used.

MR. DAVIS: But that is outside of the specifications, really. The committee was created for this work.

MR. ROSCH: To copy all the specifications is a two weeks' job for one person. We are going back to IPCEA and do it; but, it can't be done today.

MR. ZINK: You would not be scared of 15 or 20 pages, Mr. Mortenson?

MR. MORTENSON: Oh, no. It would be published in our book of standards. Once the job is done, that's it.

MR. DAVIS: Do you have a lot of rooms?

MR. MORTENSON: Yes, look at Room Key.

MR. HOGAN: As to the voltage that would exist in the various rooms, how would you work that out?

MR. ROSCH: I suggest this, that while the cable committee is trying to work up these tables and give the necessary specifications, could you and your associates work up for us which rooms are wet or dry? Then we could get together again and work out a key.

MR. MORTENSON: Yes, that can be done; but, we already have the information on the sheet entitled "Conditions Encountered in a Typical Mill," which information can be keyed into the tables. Now, Mr. Eyton, refer, please, to the room key and give us your thought on the voltages employed in the various departments.

MR. EYTON: Chip preparation, 440–2300/4160; wood yard, 600; wood room, 440–2300; digester room, 600; washer room, same; screen room, same; decker, same; stock preparation, beating and mixing, same; machine room, 6.6 kv.; finishing room, 600; coating room, 600; caustic plant, same; lime recovery, same; bleach plant, same; evaporator room, 600; recovery room, 600–4160; boiler, 600 to 4160; turbine room, 13.2; sulphur burning, 600; acid making, 600; lime room, 13.2; filter room, 600; wet machine room, 600; rag preparation, 600; washing, 600; bleaching, 600; hemp cutting, 600; wash and bleach, 600; waste paper storage, same; cutting, same; cooking, same; that's it.

MR. HOGAN: On this 2300–4160 would it be worth while to come in line with Mr. Eyton and just use overinsulation recommended for delta systems?

MR. EYTON: Good idea.

MR. HOGAN: There is but a small difference in size of insulation. For instance, on No. 8 at 5000 v. it is $^{10}/_{64}$, whereas on No. 8 at 3000 to 4000 it is $^{9}/_{64}$. Not but a small margin difference.

MR. ROSCH: That's right, we should figure for 4160 v.

MR. GRAHAM: Are there many dry rooms?

MR. MORTENSON: Yes, finishing room, boiler, turbine, coating. Those four. Wood room can be considered, can it not, Mr. Eyton?

MR. EYTON: No, I would not say so in all cases. Sulphate and sulphite, yes. Groundwood, no. I would call the sulphur burning room and the digester room dry.

MR. ZINK: Rag room is dry and dusty as hell.

MR. MORTENSON: Yes.

MR. ROSCH: Now we have the room key. I think if our committee could be pressed to work up specifications we could bring you in the necessary things.

MR. GRAHAM: Couple of things here. What are you going to do about 600 d.c.?

MR. ROSCH: 1000-v. insulation has been agreed upon.

MR. DAVIS: No, 600 v. is still in the picture. How about thermoplastic? Should the insulation be thicker?

MR. GRAHAM: The only reason for thicker insulation is to protect the wire from mechanical damage during installation.

MR. MORTENSON: Did you have a thought, Mr. Davis?

MR. DAVIS: Maybe that idea of 1000 v. is wrong.

MR. ROSCH: There is more than that to be taken into consideration, a change in size of conduit is involved.

MR. GRAHAM: 1000 v. is a rare thing. Let's be realistic and leave it 600 v.

MR. DAVIS: Now, we still haven't decided about d.c.

MR. GRAHAM: Increase the 600 v. by $^{2}/_{64}$-in.

MR. EYTON: D.C. wire, 1000 and 600 v. is going to be mixing it up.

MR. ROSCH: We, of the wire and cable industry, have felt the question of d.c. should be given consideration. Last week we discussed that particular subject. The data that we had came from our industry in general and we have had quite a bit, especially for wet locations. I think it is something that TAPPI is going to have to tell us.

MR. MORTENSON: Yes, I would say that it is. Ray Foster, at our meeting in Savannah, did stress that he had had some trouble on d.c. Smitty, however, rescinds what we found in the minutes concerning his having had many d.c. failures.

MR. GRAHAM: D.C., thermoplastic insulation!

MR. ANDREWS: What type of d.c. are we talking about, rectified or generated?

MR. SMITH: Generated, principally.

MR. HOGAN: Most complaints on d.c. within industry and utilities come from control cable in substations and such.

MR. DAVIS: That's right, there is more trouble with control cables. If these paper people don't have trouble with it, it's a new one on us. We have it in the minutes so it will be covered. It will take about 6 weeks to get the minutes out and in the meantime we will dig up something direct on d.c.

MR. ZINK: Put in a warning that d.c. is a special problem.

MR. DAVIS: Quite a lot of d.c. used. Makes it seem funny since you people say you have no trouble.

MR. EYTON: On control wiring we have had some trouble. We finally went to neoprene covered wire. We are now going to rubber insulated neoprene sheathed control cables.

MR. DAVIS: Where we recommend no braid, we shall stick to that.

MR. ROSCH: Right.

MR. GRAHAM: We decided to include paper cable.

MR. ROSCH: Right.

MR. DAVIS: I will write this all up when I go home. There are 7 tables to be set up. Then we can get together and put it in shape.

MR. ROSCH: General Electric and General Cable making the AVA, ACV, etc., already have worked out many of the tables.

MR. MCGRATH: Yes, it is pretty well cataloged.

MR. ROSCH: The problem is not a monumental thing, but will take time.

MR. MORTENSON: If we can get everything worked up so that we could present it at our Chicago meeting, that would be fine. In the meantime, we could adopt this and present it in February at our general meeting here in New York, to be augmented later.

MR. DAVIS: Final results will not look like our present recommendations at all.

MR. GRAHAM: Just in case I happen to get 5000 v. to be written up, is it to be shielded or not shielded?

MR. ROSCH: IPCEA calls for shielding. Shield above 3 kv.

MR. HOGAN: There must be a way to work in some alternate to shielding for Okonite.

MR. DAVIS: We will thrash that out when we get together, John.

Mr. McGrath: What about a circuit that operates at 2300 v. ungrounded?

Mr. Graham: Lump 2300 and 4160.

Mr. Davis: On delta operating at 2300 or on 4160!

Mr. McGrath: Do you actually subject this cable to sustained grounds? Are we designing for a condition where grounds are going to exist for months?

Mr. Mortenson: Every mill I have been connected with has had grounds that remained for months.

Mr. Smith: We always provide ground detection and we know the presence of a ground, also its probable location; but, due to the required continuity of operation we cannot shut down to repair the fault.

Mr. Hogan: That means that the ground might be sustained for a long time.

Mr. Mortenson: That's right.

Mr. McGrath: Shouldn't we differentiate between grounded and ungrounded systems?

Mr. Rosch: That will have to be explained at the bottom of the table.

Mr. Mortenson: I believe we have accomplished everything we can at this meeting.

Mr. Davis: We will see that you get what you want.

Mr. Mortenson: The TAPPI cable committee will report our joint committee program to the general meeting in February and advise that this has been adopted and should go into the record as a tentative setup. It's a start in the way of standards and specifications will come along later, such as you are now going to write. I would ask that you forward it all to us as early as you can so we can go over it and be familiar with it so we can come to a decision quickly when we meet again.

So much for that. I did invite Mr. Andrews to join our committee. In his last correspondence with me he said that he would take such an invitation under advisement. Now, Mr. Andrews, will you please accept?

Mr. Andrews: You got me over a barrel—yes! Just one point, though. Just wonder if a table on current-carrying capacities were prepared if it would be of any value to the industry.

Mr. Smith: It is available in every handbook you can get but it would be of great value as part of the TAPPI Data Handbook.

Mr. Rosch: I don't know what TAPPI has in engineering data sheets. Evidently these should be current-carrying capacity data.

Mr. Andrews: Yes, I was thinking it would be useful.

Mr. Mortenson: Submitted along with the other data.

Mr. Rosch: I would suggest that Mr. Andrews do it.

Mr. Mortenson: I would like a set of IPCEA Standards. (Mr. Mortenson receives one on the spot from Mr. Graham.) Mr. Eyton, the Technical Association of the Pulp & Paper Industry would appreciate your presence also on this committee very much. Will you accept a seat?

Mr. Eyton: I think I mentioned in my letter, Mr. Chairman, I have about four subcommittees working on different projects. Thanks a million but it would be a little hard for me. I would very much like to join you gentlemen and regret my inability to do so. However, I do appreciate the honor you are trying to bestow upon me. My hands are too full as it is. One thing I would like to bring up, we have a good many people who do not subscribe to *Tappi*. Are these reports you make to *Tappi* available to CPPA?

Mr. Mortenson: Yes, they will be made available through Mr. Foulkes. I sent him some information just the other day.

Gentlemen, I am sorry that Mr. Eyton has declined the invitation to join us. But, it is pardonable because he is the Chairman of the Electrical Committee of the Canadian Pulp and Paper Association, and I know he is a busy man.

Now, if there is nothing further to come before us we will adjourn.

RECOMMENDATIONS

For the record the meeting's final recommendations, as can be noted from the minutes above, became the following:

I. Assume that the chemicals and conditions encountered in a typical southern sulphate pulp and paper mill as shown in Exhibit I attached herewith are substantially the same for mills employing the other processes. (Sulphite, groundwood, rag, wastepaper, etc.)

II. (a) Eliminate the use of cotton or fabric outer braids on all cables wherever possible—substituting neoprene protective sheaths therefor.

(b) Make no distinction between synthetic and/or natural rubber when specifying rubber compound insulation.

(c) All cables for 600 v. working pressure or less—
A.C. Operation—
Conductors, all sizes:
1. Rubber insulation suitable for 75°C. (167° F.) operation with moisture resistance in accordance with IPCEA Standard S-19-81—Appendix N.
2. Thickness of Insulation per IPCEA Standards S-19-81—Table II—Part 3.
3. Neoprene Sheaths per IPCEA Standard S-19-81—thickness in accordance with paragraph 6.3.2.3 and quality in accordance with Appendix K.

(d) Alternate conductor size smaller than No.6 Aug.—Max. Operating Temp. 60°C. (140°F.) Thermoplastic insulation per IPCEA Standard S-19-81—thickness in accordance with Column "B" or "C" whichever is applicable to conditions of installation and quality in accordance with Appendix I.

(e) Maximum operating temperature over 75°C. (167°F.).
Underwriters' Type AVA or ACV for dry location. Type AVL or VCL for wet location.

(f) All cables for operation on 601 to 5000 kv. working pressure.
1. Ozone-Resistant Rubber Insulation suitable for 75°C. (167°F.) operation to meet requirements of IPCEA Standard S-19-81—Section 4.4 and Appendix D, and Appendix N for moisture resistance.
2. Shielding in accordance with IPCEA Standard S-19-81—Part 5.
3. Neoprene sheath per IPCEA Standard S-19-81—thickness in accordance with paragraph 6.3.-2.3. and quality in accordance with Appendix K.
4. (Alternate)—Polyethylene (manufacturer's recommendation).

(g) All cables for operation on 5001 and over working pressure:
1. Ozone-resistant rubber insulation suitable for 75°C. (167°F.) operation to meet requirements of IPCEA Standard S-19-81—Section 4.4 and Appendix D, and Appendix N for moisture resistance.
2. Shielding in accordance with IPCEA Standard S-19-81—Part 5.
3. Neoprene sheath per IPCEA Standard S-19-81—thickness in accordance with paragraph 6.3.-2.3. and quality in accordance with Appendix K.
4. (Alternate)—Paper Insulated Cable—Protected Sheath.

Maximum operating temperature over 75°C. (167°F.)
AVA or ACV for dry locations.
AVL or VCL for wet locations.

A. O. Mortenson, *Chairman*
Cable Subcommittee
TAPPI Electrical Engineering Committee

Statistics Committee

The Statistics Committee under the chairmanship of John Langmaid, Jr., of the S. D. Warren Co., Cumberland Mills, Me., sent out the following questionnaire to determine the extent to which statistical methods are used in the pulp and paper industry. Following is the questionnaire as sent out to all members of the Technical Association:

QUESTIONNAIRE ON THE USE OF STATISTICAL METHODS

1. Does your company at present use any statistical methods (statistical quality control) in the fields of:
   (a) Manufacturing or production quality control?
   (b) Research or development?
   (c) Purchasing?
   (d) Sales?
2. If the answer to the first question is negative, are you interested in the possible applications of such methods?
3. What statistical techniques, e.g., control charts, X^2 test, analysis of variance, etc., have you found most useful and which are you actually using?
4. In what departments are you actually using statistical methods? If possible please give details of any applications you have found particularly useful or you believe to be novel.
5. Do you use sampling plans (e.g., Dodge-Roehmig)?
6. If you have used statistical quality control methods at one time and later abandoned them, please state why.
7. If the Statistical Committee were to bring out a series of sheets on working methods, what shape or form would you like to see these take in order to be most helpful to you?
8. If the Statistical Committee brings out a series of data sheets would you be willing to contribute along the lines of the yellow sheets in the TAPPI Standards Book?

Responses are desired only from pulp and paper and paper converting companies. It would be desirable for members of TAPPI in any company to pool their responses so that only one response per company is received.

The responses to this questionnaire are tabulated as follows:

Statistical Conference

TAPPI Statistical Committee—University of Maine

University of Maine, Orono, Me.
Aug. 4–16, 1952

Send applications to Prof. S. H. Kimball, Orono, Me.

	Book mills	*Board and kraft mills*	*Newsprint mills*	*Foreign mills*	*All other paper mfgrs.*	*Pulp mills*	*Converters*	*Total*
1. Are Statistical Methods used?								
(a) Manufacturing or Production								
Yes	5	12	4	5	21	3	15	65
No	11	20	2	7	27	4	12	83
(b) Research or Development								
Yes	7	14	2	6	16	1	8	54
No	9	18	4	6	32	6	19	94
(c) Purchasing								
Yes	3	0	0	0	2	1	4	10
No	13	32	6	12	46	6	23	138
(d) Sales								
Yes	1	0	0	0	2	1	1	5
No	15	32	6	12	46	6	26	143
2. If (1) is negative are you interested in SQC?								
Yes	8	20	3	8	30	3	14	86
No	1	1	..	..	..	1	..	3
3. What Statistical Techniques used?								
(a) Control Charts	3	9	5	5	20	2	14	58
(b) Analysis of Variance	7	7	2	4	7	3	6	36
(c) Significance Tests	4	4	1	3	5	2	4	23
(d) c or p Charts	..	3	..	1	3	..	2	9
(e) Correlation	5	6	2	2	7	1	3	26
(f) Distribution Curves	..	1	..	2	4	..	..	7
(g) Other	1	1	..	..	3	..	3	8
4. Departments SQC used?								
(a) Production	3	8	3	3	4	..	5	26
(b) Research	6	6	1	5	7	2	3	30
(c) Testing Control	3	5	2	1	11	1	10	33
(d) Inspection Finished Product	..	1	..	..	2	..	4	7
5. Are Sampling Plans used?								
Yes	2	5	2	0	6	0	10	25

6. Have Statistical Methods been used and then abandoned?
   Only 5 mills reported that they had tried SQC and then abandoned it. The following reasons were given:
   1—Personnel shortage.
   2—Not enough interest.
   3—No new information and process variation too large.
   4—Did not improve quality.
   5—Lack of cooperation by management.
7. If Statistical Committee was to bring out a series of sheets on working methods, what shape or form would you like to see these in?
   Because of the varied types of answers to this question it is not possible to tabulate the replies. However, the consensus of those answering was that they should be in loose-leaf form $8\frac{1}{2} \times 11$. The information wanted should be practical applications of statistical methods to the pulp, paper, and converting industries.
8. If the Statistical Committee brings out a series of working sheets, would you be willing to contribute?

	Yes	*Total No. of Replies*
Book mills	11	16
Board and kraft mills	19	32
Newsprint mills	6	6
Foreign mills	5	12
All other paper mfgrs.	28	48
Pulp mills	3	7
Converters	21	27
Total	93	148

Experimental Chemical Treatments for Kraft Mill Wastes

W. A. MOGGIO

THE word "Experimental" was purposely placed in the title of this paper since chemical treatment of kraft mill wastes has never proceeded beyond the experimental stage. Insofar as the writer knows, chemical treatment of kraft mill wastes has never proceeded beyond the laboratory stage, with one exception, which will be discussed later.

Published information in technical journals dealing with this subject is nonexistent. The available information is to be found only in widely scattered laboratory reports of various kraft mills and research organizations. In general, the laboratory reports indicate the termination of further development work due to an almost universal absence of potentially successful economical application of the laboratory process. This probably explains the lack of publications in technical journals.

The treatment of kraft mill wastes for the purpose of pollution abatement is directed toward the removal of color and toxic and oxygen-consuming materials from the waste. Chemical treatment methods will remove both color and oxygen-consuming materials. A high degree of color removal is possible with chemical treatment while the removal of oxygen-consuming materials is more or less incidental to the color removal although, in some instances, B.O.D. removals in the range of 50% are attainable.

In any waste treatment process the costs involved are of foremost importance since there usually is no monetary return of these costs in the form of a salable product. Therefore, in order to be economically feasible a treatment process must keep chemical, equipment, operating, and maintenance costs at a minimum. This is particularly true in the case of kraft wastes since, because of the large size of most plants, the quantities of waste waters to be treated are large, measured in the millions of gallons per day rather than ten or hundred thousands. This fact must be kept in mind when one examines the chemical demands for treating these wastes.

In general, the chemical compounds utilized in most experimental studies consisted of the usual coagulating and precipitating agents such as alum, ferric sulphate and lime, and various combinations of these. In addition, sulphuric acid, char, clay, various activated carbons, activated silica, ferric chloride, chlorinated copperas, phosphoric acid, waste pickle liquor and a barium alumina silicate compound have been used for color and/or B.O.D. removal.

In the treatment of total kraft mill wastes using H_2SO_4 (66° Bé.) it was found to require from 4500 to 6000 pounds per million gallons of waste. Chemical costs alone at present-day prices would be from $40 to $60 per million gallons of waste treated. Color removals would be better than 90%. In using sulphuric acid corrosion-resistant equipment would be necessary and the effluent would need to be neutralized before discharge into a stream. In addition, large quantities of gelatinous sludge are obtained which are extremely low in solids content. The handling and disposal of this sludge would be a difficult problem and no means of chemical recovery is available. B.O.D. removals were low.

The use of alum on total kraft mill waste required 1500 pounds per million gallons. In this case the cost of chemicals alone would be about $63 per million gallons at present alum prices. Here again the problem of voluminous sludges, low in solids content, presents itself. Another method of treatment tested utilized a barium alumina silicate compound, $BaO[(BaO)_3Al_2O_3 \cdot (BaO)_3SiO_2]$ in conjunction with alum. Two thousand two hundred pounds per million gallons of alum is first used to precipitate the organic matter followed with 5600 pounds per million gallons of the barium compound. The treated water is claimed to be free from color, organic matter, magnesium, calcium, and sulphates. The economy of the process depends on the reuse of the treated water back in the mill, plus the recovery of the precipitated barium compound. The use of the barium compound without the alum required 9600 pounds per million gallons in order to remove the color from the waste. Estimated costs for the alum-barium compound treatment in 1939 were $77,000 for the construction of a plant for the treatment and recovery of the barium compound plus $241 per day net cost of operations for treating 20 m.g.d. Even at 1939 costs the process is obviously impractical from an economic standpoint.

Stored or lagooned kraft mill wastes were treated in the laboratory with various chemicals. The following table summarizes the chemical demands, the per cent reduction in oxygen consumed value, and the chemical costs at present-day prices.

Chemicals/million gal. stored waste	*% Reduction oxygen consumed*	*Chemical cost/million gal., $*
740–8000 lb. H_2SO_4	11–71	13–80
1600–5600 lb. H_2SO_4 + 1600–3200 lb. alum	42–88	84–192
1600–8000 lb. alum	32–85	68–340
8000 lb. lime	21	40

All of the above treatments resulted in large quantities of gelatinous sludge. The disposal problem of the sludge was such that the material could not be dewatered by vacuum filters or centrifuges. In addition, where sulphuric acid was used a corrosion problem presented itself and neutralization of the clarified waste was necessary before discharge. In addition to the chemical costs summarized above the costs of the equipment, operation, maintenance, etc., must be added. Obviously, the costs are far too excessive for the results obtained.

Acid bleach plant liquors have been treated with various activated carbons for color removal. Color removals of 95% are attained but the requirements for activated carbons are in the range of 13,000 to 17,000 pounds per million gallons of waste. Assuming an average price of $0.11 per pound for activated carbon the initial chemical cost alone would be $1430 to $1870 per million gallons of bleach plant waste. Recovery of the activated carbon is possible but the effectiveness of the carbon decreases with each recovery cycle plus the fact that make-up is necessary due to losses during recovery. In addition, the equipment required for dewatering, drying, and reactivating such large amounts of carbon would run into a sizable expenditure. Obviously such an installation is impractical from an economic standpoint.

Treatment of bleach plant wastes using lime, ferric sulphate-lime, and alum-lime combinations has been studied in the laboratory. Dosages using lime alone ranged from 7150 to 25,100 pounds per million gallons of waste and B.O.D. reductions of 2 to 15% and color reductions of 24 to 70% were obtained. With the ferric sulphate-lime combinations, ferric sulphate dosages ranged from 1430 to 7150 pounds per million gallons and lime dosages from 5720 to 14,300 pounds per million gallons with B.O.D. reductions of 2 to 18% and color reductions of 34 to 84%. With the alum-lime combinations, alum dosages ranged from 1430 to 7150 pounds per million gallons and lime dosages of 7150 to 14,300 pounds per million gallons with B.O.D. reductions of 0 to 18% and color reductions of 45 to 80%. Chemical costs for lime treatment ranged from $35 to $125 per million gallons, for ferric sulphate-lime treatment from $50 to $179 per million gallons and for alum-lime treatment from $106 to $375 per million gallons.

W. A. MOGGIO, Resident Engineer, National Council for Stream Improvement, Louisiana State University, Baton Rouge, La.

On a mixture of bleach plant-pulp mill wastes, using the same chemicals, the dosages using lime alone ranged from 14,300 to 28,600 pounds per million gallons of waste with B.O.D. reductions of 10 to 20% and color reductions of 58 to 68 %. With ferric sulphate-lime combinations the ferric sulphate dosages ranged from 720 to 1430 pounds per million gallons and a lime dosage of 3580 pounds per million gallons with B.O.D. reductions of 1 to 25% and color reductions of −202 to 91%. With alum-lime combinations the alum dosages ranged from 720 to 7150 pounds per million gallons and lime dosages from 3580 to 7150 pounds per million gallons with B.O.D. reductions of 7 to 23% and color reductions of −40 to 63%. Chemical costs for lime treatment ranged from $72 to $144 per million gallons, for ferric sulphate-lime treatment from $29 to $232 per million gallons, and for alum-lime treatment from $51 to $356 per million gallons. The precipitates obtained were all fast settling and compacted to 5% or less of the total volume with 30 minutes' sedimentation. They were gelatinous in nature and difficult to dewater and would present a difficult sludge disposal problem. The possibility of chemical recovery was absent except in the case of the lime treatment. Lime had to be used with ferric sulphate in order to raise the pH and prevent the development of highly colored iron-lignin and iron-tannin compounds. Lime was necessary with the alum in order to furnish the necessary alkalinity for the precipitation of the aluminum compounds.

Critical examination of the preceding data leads to the obvious conclusion that chemical treatment of kraft mill wastes is too costly. In addition to the high chemical costs, the costs of equipment, operation, and maintenance must be considered. The cost problem as well as the technical aspects are further complicated by the problem of the large quantities of sludge formed which must be disposed of satisfactorily. These sludges are gelatinous and difficult to dewater and to date have shown that they cannot be successfully handled on vacuum filters, precoat filters, and centrifuges. In addition to the sludge problem some of the chemicals used would require corrosion-resistent equipment, which would add to the cost and difficulties.

By-product recovery or chemical recovery would assist considerably in bringing down the cost of treatment of kraft mill wastes. Recovery of by-products from kraft mill wastes has been completely unsuccessful to date. However, the possible recovery and reuse of the chemicals used in kraft waste treatment shows definite promise of success. This possibility narrows down to the recovery of lime since, initially it is one of the cheapest chemicals, it does a good job of color and B.O.D. removal, and it offers the enticing possibility that it can be handled and recovered in existing kraft mill equipment and operations, all of which will have a decided effect in keeping treatments costs at a minimum and within economic feasibility. The use of lime and its subsequent recovery is not, however, a simple problem and the difficulties of sludge handling are encountered.

Evidence that lime treatment of kraft mill wastes offers the best possibility of success is the fact that of all chemicals used lime treatment is the only one which has gone beyond laboratory experimentation. One of the kraft mills in the South has been investigating, for some time now, a method of lime treatment for color removal in a 100-gallon per minute pilot plant installation. The results obtained are very promising. Briefly, the process consists of lime treatment of total mill waste followed by carbonation to precipitate any excess lime in solution and the recovery of the lime from the sludges by dewatering and calcining in a kiln. The greatest difficulty encountered has been the dewatering of the lime-organic sludges and studies are under way on the use of centrifuges for dewatering. The calcining of the lime-organic sludges will also have to be investigated and a special type kiln may need to be used. Lime dosages have been in the range of 2000 to 3000 lb. per million gallons of waste.

Kraft bleach plant waste treatment studies, utilizing a lime-carbonation process, are under way in the laboratory of the National Council for Stream Improvement's kraft waste treatment project at Louisiana State University. Although similar to the pilot plant process it contains variations of a basic nature warranting further study and evaluation.

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Sulphur Dioxide from Sulphides by FluoSolids

N. A. JULL and W. T. MARSTON

Cutbacks in supplies of elemental sulphur have quickened the interest of sulphite pulp producers and sulphuric acid manufacturers in alternative sources of sulphur. Pyrite and pyrrhotite are iron sulphides with theoretical sulphur content of 53.4 and 40.4%, respectively. Chalcopyrite is a copper sulphide, sphalerite a zinc sulphide with sulphur contents between 30 and 35% in both cases. All are commonly produced or available in adequate quantities in Canada. Pyrite, with its very high sulphur content, should give the lowest unit sulphur cost except where zinc-bearing sulphides or copper sulphides can be treated in transit between mine and refinery on favorable terms. The residue or calcine from pyrite may have some value as iron ore while the residue from copper or zinc sulphides has a very high metal value. It will be shown later that recovery of these metal values can be simplified by FluoSolids roasting, but the location of many pulp mills and acid plants would add too great a shipping cost to the price of the metal ore.

The use of sulphides in place of elemental sulphur is attractive except for the necessity of adopting new techniques. The supply of pyrite and pyrrhotite in Canada is practically inexhaustible and promises to equal or improve upon the present delivered cost of a unit of sulphur. Equality of cost among Canadian users should result from the wide distribution of sulphides in mineral deposits across Canada.

Sulphides have been used for years in many parts of the World for SO_2 production, but former plants were subject to mechanical and process disadvantages which discouraged their use when brimstone was available. The FluoSolids process is mechanically very simple and appears easily adaptable to sulphur dioxide production, so that the burning of sulphides may now be considerably simplified.

THE FLUOSOLIDS PROCESS

The basis of the FluoSolids process is the suspension of solid particles in a stream of gas which is moving vertically upward through a perforated constriction plate. The gas velocity is just sufficient to support the particles without carrying them all upward, and the result is an expanded bed of solids in turbulent agitation, much like a vessel of water into which a large amount of air is being diffused. This violent mixing results in complete uniformity in particle size distribution, chemical composition, and temperature throughout the fluid bed. The addition or removal of heat at any point in the bed, or immediately adjacent to it, results in an immediate and uniform temperature change throughout the bed. So excellent is the heat transfer between the solid particles and the gas film by which each is surrounded, that gas and solid particles are always at substantially the same temperature. Thus, the temperature of the fluid bed can be automatically controlled by the injection of water. The loss of heat in evaporating this water controls the temperature of the whole bed. The speed and uniformity of this control can be seen in the readings of thermocouples situated

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throughout the bed, when the spray water is varied. Under automatic control, temperature is easily held constant within 10 or 20°F.

The bed of fluidized solids resembles a liquid in ways other than appearance. It will flow over weirs and through pipes, and exerts hydrostatic head, indicating a density about one third of the specific gravity of the solids. Therefore, as feed is introduced to the bed, roasted material overflows to the cooling system, here it is joined by the dust product from the cyclones.

The gas velocity through the void spaces of the fluid bed is much higher than in the freeboard space immediately above the bed. This sharp reduction in gas velocity as it leaves the reaction zone causes most of the entrained particles to drop back into the fluid bed and to be uniformly distributed therein. Dust carry-over from the reactor to the cyclones varies with the size distribution of the solids fed to the process, and is generally in a range between 20 and 40% of the total reactor product. Most important, this dust is fully roasted material since the rapid heat transfer brings new feed up to bed temperature instantly, and roasting is almost immediately complete.

From the above fact, it is apparent that the fluid bed consists of fully roasted material. In other words, the detention of solids in the fluid bed is particularly useful during power failures or other shutdowns since by merely stopping feed and air, the bed is defluidized and the solids settle down on the constriction plate. Commercial units have been shut down in this way for periods up to 3 days, after which it was merely necessary to push two buttons, starting air and feed, and the process was again in balance at roasting temperature within a few minutes. Introduction of auxiliary fuel is necessary only on initial start-up, or following extended shutdowns.

Here is an example from data on one of the FluoSolids roasters operating in the Red Lake mining area. The sulphides roasted are diluted with gangue, of course, and the total sulphur in the feed at the time of this test was 23.8%. Note the remarkably rapid attainment of full gas strength, an excellent SO_2 content for this feed.

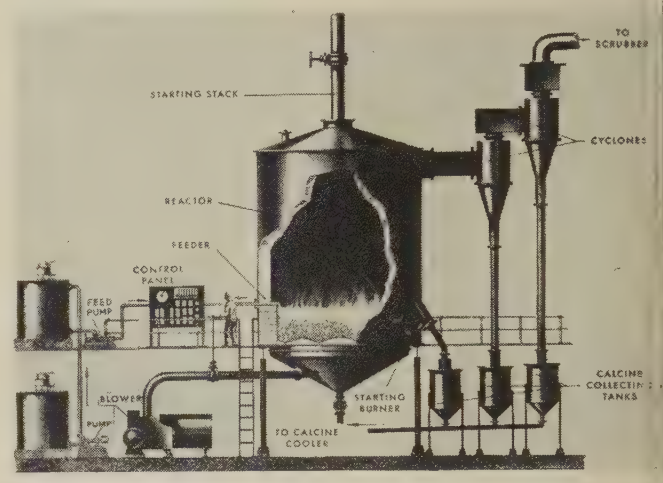
Time	*Remarks*	*% SO_2*	*% O_2*
4:00	Air on . . . no feed	0.0	20.6
4:03	Feed pump started		
4:07		13.0	2.7
4:15	Air flow steady at 1825 c.f.m.	13.2	1.3
6:15		13.0	2.0
6:22	Air flow reset to 1725 c.f.m.		
6:25		14.5	0.6
6:32		14.6	0.4
6:39		14.2	0.8
	Average feed analysis for shift, 23.8% sulphur		

Reactor size, then, is determined by the air volume required to supply sufficient oxygen for the reactions taking place in the fluid bed, and the linear upflow rate which can be tolerated by the size of particles to be fluidized. This "space rate" is customarily calculated as the linear gas velocity in the freeboard immediately above the bed. Coarser feed solids permit a higher space rate without excessive dust carry-over, and hence a smaller reactor. Although in limestone calcination feed can be as coarse as 6 mesh, the higher specific gravity of pyrite necessitates a top size of about 14 mesh (approximately 1.2 mm. in diameter).

In spite of the turbulence in the fluid bed, wear on the reactor walls appears to be negligible. In the first sulphide-roasting installation, a thin layer of refractory cement was brushed onto the inner surface of the brick lining, and after four years of continuous successful operation, no visual evidence of wear can be found, and brush marks are still visible. From a maintenance standpoint, the fact that there are no moving parts in the high temperature zone is an obvious advantage of the process.

HANDLING OF SOLIDS

Storage of sulphides ahead of the roasting operation is a problem requiring individual solution, depending on geography and shipping conditions. Some users in Canada, dependent upon water shipment, will have to store a minimum of 6 months' supply in sizable piles. Moisture content of less than 3% is considered by some to risk spontaneous combustion in the pile, particularly where it is possible for air to enter at the bottom and work up through the pile. With higher moisture contents, freezing could be a nuisance, but this will occur only to a depth equal to the frost layer in the ground, and some users tunnel into a pile from the side, caving down the frozen dome as warmer weather approaches.



The Dorrco FluoSolids system for SO_2 gas production

The solids must be conveyed from storage to a slurry agitator in which water is added by instrument control to make a pulp of the desired water content, usually 26%. As required, this slurry is pumped by means of a centrifugal pump to a similar agitator which serves the feed pump. This latter pump is of the constant displacement type equipped with a variable speed drive which could be instrument-controlled. Thus, a uniform rate of solids feed is established, leading, as will be shown, to the production of SO_2 gas which is uniform in quality and controllable as to quantity. This exact process control is one of the most appealing and unique features of the FluoSolids system.

It is immediately apparent that moisture content of sulphides as received is of no consequence to the FluoSolids process since the preferred method of feeding is to pump in a slurry containing 20 to 25% water. This quantity of water still leaves an excess of heat to be dissipated by the instrument controlled water spray which maintains the fluid bed at the desired temperature. Commercial reactors have operated for long periods with the sulphur content of the solids as low as 15% and using a slurry feed containing 20% H_2O.

Process control, from the point of view of this discussion, will be concerned chiefly with its effect on the gas produced. However, the degree of control is such that the sulphur left in the calcine may be almost any desired amount and can be uniformly maintained. When pyrite or pyrrhotite is the raw material, the iron oxide residue (hematite, Fe_2O_3, or magnetite, Fe_3O_4) is a potential iron ore. For blast furnace use, this must first be sintered, and a certain percentage of sulphur can be left in it, if desired, for use as fuel in the sintering operation. Where full sulphur utilization in roasting is the goal, total residual sulphur in the calcine can be uniformly less than 1%.

Where sphalerite has been roasted, zinc solubility is com-

monly 90 to 95% largely due to minimum formation of ferrites with the iron which is invariably present. Sulphating is held to a minimum. In one type of copper roasting sulphating is desirable for leaching, and 90% of the copper can be made water-soluble, another 5 to 9% being soluble in weak acid. This paper is meant to deal mainly with SO_2 production, but we mention the above facts as examples of the process control inherently available in the FluoSolids process. There is no magic involved. All points within the reactor are within a very few degrees of identical temperature, as outlined above. Solids passing through the roasting operation cannot be subjected to temperatures higher or lower than the optimum even for a few seconds, as may be the case in other processes. Solids and gas are always present in correct proportions due to the accurate feeding possible. In general, the process lends itself so well to exact control, automatic when desired, that commercial results can quite naturally approach the theoretical.

The uniformity throughout a fluid bed, which has been described above, makes possible a point of great convenience to prospective users of FluoSolids. Laboratory reactors, which are essentially just small vertical sections of a commercial one, give results which have been accurately checked time and again by full-scale units. Test work is therefore a particularly reliable method of predicting process results. Space rate, optimum temperature, gas strength, and calcine analysis can be predetermined with remarkable accuracy.

The calcine overflowing from the reactor, along with the dust from the cyclones, must be cooled for further handling, and in the case of pyrite roasting, this is most commonly accomplished by water quenching. The calcine slurry can then be handled in a dust-free manner; thickened and filtered if desired, or pumped to disposal. Dry cooling is feasible where required by the ultimate destination of the calcine, and in such a case, the residues are discharged from the reactor and cyclones through suitable seals which prevent gas leakage, into a standard type of dry cooler, several of which are available. However, the more usual water-quenching method recommends itself to pulp mills particularly, and to all users where practicable, in view of the neatness and convenience afforded.

Where geographic location or economics prevent use of the calcine as metal ore, disposal of calcine will be one of the major problems connected with conversion from use of elemental sulphur to the sulphides. If pumped to disposal areas as a slurry, the dumping ground should be constructed in such a manner that dust nuisance is minimized. Slurry is introduced at one side of the pond, so that coarse material is handy for use in building up the retaining walls. Water is taken off a central, adjustable overflow pipe, maintained at a level sufficient for dust control. In winter, the pipe can be lowered to reduce the pool area, and enough heat is present to avoid freezing, particularly since there is a steady flow. As required, the level is lowered and men patrol the banks armed with a hoe, with which they rake up the coarse material to build up the retaining walls.

Even large pulp mills using, say, 15,000 tons of sulphur annually will have for disposal only about 19,000 tons of calcine. This could probably be contained in an area of roughly half an acre, at a depth of 10 feet which is not much of a problem compared with that of mines discarding 100,000 to a million tons of tailings annually. Still, it is recognized that pulp mills and sulphuric acid plants may not always have as much available waste land as is found in mining areas, and in some locations, disposal to a body of water might be feasible. To those users situated in more urban areas, the possibility of selling the calcine for blast furnace feed is much more likely.

GAS PRODUCTION AND HANDLING

The paramount interest of sulphite pulp mills and sulphuric acid manufacturers is in a supply of sulphur dioxide gas at temperatures around 100°F., free of entrained solids and contaminating gases such as sulphur trioxide. The production of such a gas from pyrite will now be considered.

Air is introduced to the wind box by a centrifugal blower at a uniform and controlled rate sufficient to supply oxygen for the sulphur dioxide requirement. This air stream is distributed uniformly under the reaction zone by numerous small holes in the constriction plate which separates the wind box and the reaction zone. Although the detention time of the gas in the bed is less than 4 seconds, the oxygen in the air is converted to sulphur dioxide in the gas stream, or transferred to iron oxides in the fluid bed. The gas is now at the temperature of the fluid bed, is laden with dust, and will have a substantial water vapor content.

Since no user of sulphur dioxide could tolerate the dust content, a two-stage series of hot cyclones is used to reduce this this dust content to a probable maximum of 5 grains per cubic foot. These units are refractory lined; and deliver the dust to the cooling operation where it joins the main reactor overflow. The hot, relatively dust-free gas, containing very roughly 25% water vapor by volume, may now be subjected to a variety of treatments to accomplish final dust removal, cooling, and condensation of the water vapor.

In burning elemental sulphur, just under 4000 B.t.u. per pound of sulphur are released; in burning pyrite about 5700 B.t.u. per pound of sulphur are released due to oxidation of the iron. However, in the case of pyrite, a portion of the sensible heat is removed in the calcines, so that actually only about 30% more heat must be removed from the gas with pyrite than with elemental sulphur. With its water vapor content and lower SO_2 strength, the volume of gas from pyrite burning will be larger, and it will usually be necessary to install additional gas cooling facilities for this reason. If the pyrite contains around 50% sulphur, theoretical gas strength attainable is 16.2% SO_2, against 21% SO_2 theoretically possible in brimstone burning.

The historic choice for heat recovery from the gas has been a waste heat boiler. However, waste heat boilers do not appear to justify themselves economically for the average producer who needs 15 to 20 tons of sulphur per day and are, in fact, debatable at present-day costs unless the sulphur requirements are in the neighborhood of 50 tons per day. That is, a steam credit of 50 or 60 cents per thousand pounds will not usually support the operating cost and still return the investment in a reasonable time, except for larger installations. The necessity of hiring additional stationary engineers, due to the remote location of the acid plant with relation to the existing steam plant, adds greatly to the cost.

However, there is another choice, whereby two-stage scrubbing and cooling towers of various commercial types can be used to remove dust particles and to cool the gases to a point where the present gas-cooling equipment can handle it, or right down to acid tower temperatures. These are simple units in which sufficient water is evaporated into the gas in the first stage to drop the gas instantly to its wet bulb temperature (the advantage of sudden cooling through the sulphating range is obvious); sprays of cool water in the second stage complete the gas cooling and most important, condense the water vapor carried. This second stage may be made a lucrative source of waste heat by installing a heat exchanger and circulating through it the condenser spray water. This heat exchanger then becomes a source of hot water at, say, 150°F., of which few mills have an oversupply. The economics will usually indicate the installation of such a unit to augment present gas cooling facilities. Where a waste heat boiler is installed, the scrubber-cooler towers will still be necessary for removal of entrained solids.

When the exit gas temperatures from a waste heat boiler (usually 600 to 650°F.) are compared to the temperature of the gas from a scrubber-cooler tower (usually less than 200°F.) it becomes immediately apparent that the scrubber-cooler

tower recovers a greater proportion of the available heat. The FluoSolids pyrite burner, using wet feed and water cooling, produces roughly 2 pounds of steam per pound of sulphur burned. A roasting plant with no water introduced would give 50% more steam since no heat would pass through the boiler tied up in water vapor. However, with any roaster, a heat exchanger would produce hot water equivalent in B.t.u. content to 100% more than a boiler following a wet feed roaster. That is, the heat exchanger recovers more heat than a boiler, no matter what the roaster. It seems certain that the increased capacity of the scrubber-cooler and the heat exchanger will be less costly than the waste heat boiler. So, if heat in the form of hot water is as valuable as steam, the heat exchanger would seem the economical choice. Gas cooling is an established practice, and from an assessment of present plants, the practical operation of water-spray gas coolers seems simple. However, in all cases, individual assessment would be necessary.

The FluoSolids system is a pressure system (right to the acid towers if desired) in that all air is supplied, through a standard air filter, by a centrifugal blower. There are two advantages here—no fan on the hot, dirty gases, and no opportunity for dilution of gases by leaks which could occur in a vacuum system. Depending on the latter part of the equipment on the gas stream, the total pressure in the wind box may be as much as 5 p.s.i., but average operation requires less.

Gas strength is remarkably high, compared with theoretical, and a comparison with average brimstone burning is interesting. These excellent results are simply a matter of closer control of the two reacting materials than is possible in conventional burners.

Pulp mill operators do not like any formation of sulphur trioxide because of liming effects in their acid system. In the FluoSolids system, conditions may be established whereby SO_3 formation is minimized to the point of virtual elimination. The temperature of gas and solids is uniform throughout the reaction zone. It will bear repeating that no particle spends any time in the reaction zone above or below controlled reaction temperature. This is seldom so in other processes. Conversion of SO_2 to SO_3 in the presence of iron oxide has been found to be substantially zero at 1000°C., so that operation of the FluoSolids system at a controlled temperature in the 900 to 1000° range assists in minimizing SO_2 formation. Further, conversion is markedly less for gases of high SO_2 strength. This process offers the highest percentage of SO_2 of present pyrite burners, and at the same time the least excess oxygen, which, of course, is required for the conversion.

INSTRUMENTATION

In the existing FluoSolids installations a satisfactory degree of automatic control is employed considering that the mining industry in general leans somewhat less in that direction than do some others. A temperature recorder-controller operates a valve controlling the spray water for temperature control, and the variation in temperature is less than 20°F. A slurry density controller regulates the water flow to the first agitator tank thus maintaining precise percent moisture in the feed slurry. Air flow is recorded but manually controlled, and feed rate is also under manual control. Full-time operators are employed, and their scant duties offer no incentive toward further mechanization unless it should be decided to dispense altogether with their services and put the roasters under the care of the mill operators. In one of the most recently initiated installations (to begin operation about a year hence), the roaster building is to be connected directly to the mill building, and the mill operators may possibly have the responsibility for roasting as well. In this case considerably more automatic control could be utilized if desired.

A multiposition temperature recorder indicates the uniformity of temperature throughout the fluid bed, and records gas temperatures at additional points between reactor and stack. Differential pressure gages indicate pressure drops across constriction plate, fluid bed, etc., thus providing a means of detecting any plugging in the system, or defluidization of the bed. Partial defluidization would also be sharply indicated by isolated points of falling temperature on the recorder chart.

Since the feed slurry dilution is maintained at a constant value by the density controller, the setting of the variable speed drive on the feed pump determines the solids feed rate. This is amenable to automatic control to allow for variations in the sulphur analysis of the feed solids, or changes in the air input, and the control could be exercised by a continuous sulphur dioxide or oxygen analyzer, on the reactor exit gas. The arrangement would suit both gold ore roasting, in which the degree of oxidation of calcine requires control, and SO_2 production, in which gas quality is the important feature. Either a predetermined SO_2 percentage, or a maximum oxygen content of, say, 0.5%, could be set on the controller, depending on the type employed, which would vary the feed rate to match its sulphur content with the oxygen entering in the air. The volumes of the slurry agitators are such as to hold about 10 hours' supply each. Sulphur will not, therefore, change rapidly, but the oxygen input may, due to atmospheric changes and due to changes in gas demand.

The authors visualize a control arrangement which includes a flow controller on the air stream, measurement being taken at a point just following the scrubber, where the gas is at a low and fairly constant temperature and pressure. Time lag for control would not be more than 45 seconds. In our suggested arrangement, then, it should be possible to set the control instruments for desired gas quantity and quality, and rely entirely on automatic control.

When roasting a mixture of sulphides of various sulphur contents, the SO_2 controller would have to be set for some predetermined value based on the feed analysis. The volume of the slurry agitators prevents rapid changes in sulphur content anyway, so that the controller would normally alter feed rate only to match the air input. The point to watch is the danger of setting an SO_2 demand at the controller which is not attainable by the sulphides in use, causing incomplete utilization of the feed sulphur.

If the oxygen analyzer were used, feed rate would be automatically varied as before, bringing in enough solid feed to use up the oxygen provided, leaving a constant excess of, say 0.5%. No alteration in setting need be made by the operator with different feeds, but if a mixture of sulphides is used, the base strength could vary with different sulphur to iron ratios. Even so, the variation in gas strength would be limited to 3% maximum, which is not too great a drawback.

SUMMARY

Of the various alternatives to brimstone burning, pyrite burning would appear to have many advantages. The FluoSolids process for sulphide burning is comparatively low in capital cost, has unusually low maintenance cost, and offers the highest degree of process control, which is remarkably subject to automatic operation. Even on manual control, operating attention is only occasionally required. Gas strength is higher and more uniform than otherwise obtainable from sulphides, and sulphur trioxide formation lower. Sulphides of almost any sulphur analysis, and of any moisture content, can be handled. Disposal of calcines may be a problem for some users, but their potential value as metal ore goes far toward balancing this disadvantage. Many users should expect an ultimate reduction in their unit sulphur cost after converting to sulphides, and a more controllable gas-producing plant.

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Instrumentation Studies. LXIX. General Discussion of the Measurement of Adhesion and Cohesion

J. A. VAN DEN AKKER

Following a review of existing methods for evaluating adhesion and bonding strength, this report presents a critical consideration of the stresses involved in the measurement of strength of bond in tension, compression, shear, torsion, and in special tests. The manner in which various factors can result in stress intensification and failure at spuriously low apparent stress is described in some detail. Suggestions for the improvement of instrumentation of adhesion measurement are given. The report concludes with a section on the influence of factors relative to use requirements.

THERE is considerable timely interest in the measurement of strength of bond—a topic which the American Paper and Pulp Association has suggested be made the subject of a critical discussion. In addition to the ever-important problems of evaluating the internal, transverse bonding strength of paper and the strength of bond between surface coatings and the base stock, the development of paper-base laminates has introduced new combinations of paper and metals, paper and wood (plywood), plastics, and other materials. Improvements in the "welding" of these new combinations will depend in part on the evolution of satisfactory methods for the evaluation of adhesion. Greatly increased research and developmental work on containers has called for new or improved methods for measuring ply-adhesion, strength of bond between liners and corrugating medium, wet strength of bonds, scuffing resistance of paperboard surfaces, and evaluation of the "tackiness" or adhesiveness of waxes and other materials employed in the heat sealing of containers. Although it appears that the erasability of writing and drawing papers is preferably to be evaluated by means of a device which abrades the surface, it is certainly of ultimate interest in a research study to investigate the internal bonding strength from the point of view of possibly relating it to erasability.

LITERATURE REVIEW

The literature on methods for evaluating adhesion is meager, and very little has been published on the molecular theory of adhesion.* The reader interested in the theory of bonding between dissimilar substances should refer to recent articles by de Bruyne (*1*) and by Butterworth (*2*). Mechanical analysis of existing methods for evaluating adhesion—the subject of the present report—has apparently received little, if any, attention.

Much of the literature on methods for testing adhesion was covered in the preparation of the Institute's work on "Determination of the bonding strength of paper," which has been reported to the Association in Parts I, II, and III of Report No. 31† (*3, 4, 5*). That review of the literature is presented in Part I of Report No. 31, and it would be of convenience to the reader to have a copy of that report at hand during the study of this report. Additional references of interest to the reader are the following. Annis (*6, 7, 8*) has published a series of articles on the wax pick test. Bekk (*9*) has described his "surface tensile" or "resistance-to-picking" tester in English. Bradner and Montgomery (*10*) have covered a method for testing coated paper in a U. S. patent. Brown (*11*) has developed tests for ply-adhesion in multi-ply paperboard. In a study of ply-adhesion in laminated sheets, Doughty and Baird (*12*) proposed a method for measuring the force required to separate two plies. Halladay and Luey (*13*) have described a tensile test, using a wax adhesive for evaluating the ply-bonding-strength of paper and paperboard. Kessler (*14*) designed tensile tester adapters which may be waxed to the two surfaces of coated paper and inserted in a tensile tester to measure the bonding force. Landes (*15*) compared Dennison and K & N waxes (for pick tests) and studied the influence of the pigments employed in the manufacture of coated paper. Simmons (*16*) has described a method for directly comparing the picking resistance of a paper with that of a reference paper. Sutermeister and Osgood (*17*) have developed an apparatus and method which measures the internal bonding strength of paper by direct application of a transverse force. An early test for the measurement of the transverse strength of paper was described in the *Paper Makers' Monthly Journal* (*18*).

Of special interest is the new ASTM Technical Committee on Adhesives (Committee D-14) (*19*). The first of several subcommittees of D-14 is devoting its attention to strength tests ("shear, tension, compression, torsion, vibration, etc."). The findings of this committee are anticipated with considerable interest.

ANALYSIS OF METHODS FOR BOND STRENGTH TESTING

Classification of Methods

The devices and procedures described in the literature for the testing of strength of bond are based on relatively few elementary concepts. These concepts may be classified in idealized form as follows. (In this

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* Since the issuance of this report in 1945, an excellent book on the subject has made its appearance: de Bruyne, N. A., and Houwink, R., ed. "Adhesion and Adhesives." New York, etc., Elsevier Publishing Co., 1951, 517 pp. Part One of this book is especially to be recommended to the technical reader, and also Chap. 9 (of Part Two) because of its pertinence to the present report.

† The emphasis in the work presented in Report No. 31 was on the resistance of paper to "picking" (surface rupture due to stresses arising in printing and similar operations).

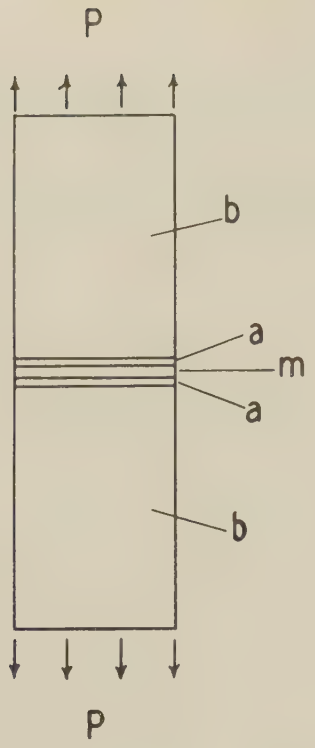

Fig. 1

and following discussions, the words "stress" and "strain" have their usual technical sense.)

Tensile Strength. The strength of an adhesive or of the adherend under tensile stress is commonly evaluated by joining the materials under test to two solid blocks or cylinders, as shown in idealized form in Fig. 1. Failure is ordinarily assumed to occur in the weaker of the two substances, *a*—the adhesive and *m*—the adherend; the latter may consist of a single sheet or several sheets laminated together (the thickness of layers in Fig. 1 and succeeding figures is exaggerated). The stress is assumed to be constant throughout the materials *a* and *m*. Usually, an attempt is made to fix the cross-sectional area at a definite value, and the strength is calculated by dividing the load at failure by the cross-sectional area (that is P/A).

Compression Strength. The idealized arrangement shown in Fig. 1 is employed, with the directions of the loading forces reversed.

Shear Strength. Shear strength is commonly evaluated by joining the sheet material *m* to a pair of sheets or bars with an adhesive *a* as shown schematically in Fig. 2a; an idealized arrangement is shown in Fig. 2b. The shear strength is calculated as P/A in the former case, and as $P/2A$ in the latter, where A is the area of any single layer. The shear stress is assumed to be constant throughout the layers. In the testing of glue joints where wood is the adherend, shear stress is commonly employed, with loading forces the reverse of those indicated in Fig. 2a (see reference *11* to Allen and Truax, Report No. 31, Part I).

Torsion. The stress in a shaft subjected to torsion is principally shear stress, of magnitude varying from zero at the axis to a maximum value at the surface of the shaft. When the two ends of shafts on a common axis are bonded together and the system is placed under torsional loading, the adhesive is subjected to shear stress. Ordinarily, the mechanical characteristics of the adhesive are not the same as those of the adherend (in this case the material of the shafts) and, hence, it is not possible to apply relatively simple formulas to the calculation of the shear stresses in the adhesive. It would appear, therefore, that more fundamental and, hence, more generally useful data should be obtainable with the shear strength test described in the preceding paragraph. However, in view of the above-mentioned absence of exact mathematical relationship between shear stress and torsional loading, it may sometimes be desirable to perform a torsional strength test of the "use-requirement" class, in which the testing simulates the actual conditions of stressing. An example would be a lever, a flat face of which is cemented to the end of a rod, to which the lever transmits a torque.

Special Methods. There is an important class of test methods which are designed to evaluate the strength of a bond under conditions not amenable to mathematical analysis.

1. Wax Pick Test. This well-known test has been investigated on the Instrumentation Program and is discussed in Report No. 31, Parts I, II, and III (*3, 4, 5*). It is indirect and appears to be based on the notion that the transverse bonding strength in paper may be evaluated on a relative scale by comparing the strength of bond with (a) the tensile strength of a series of graded and standardized waxes, (b) the strength of the adhesive bond between the paper and such waxes, or (c) the tensile strength of a layer in the paper surface impregnated with such waxes. The foregoing multiplicity of alternative comparisons does not refer to alternative test procedures, but to uncertainty in the theoretical interpretation of the wax pick test.

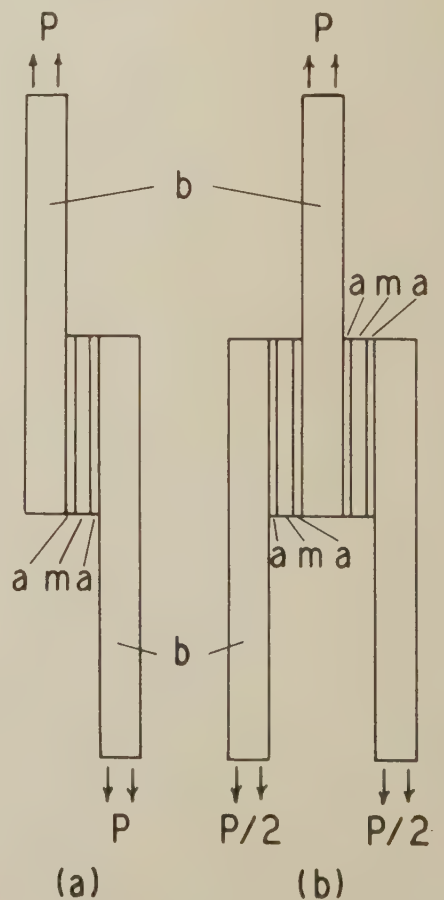

Fig. 2

2. Ply-Adhesion Between Strips. Two strips of the sheet material under test are bonded together over the whole area of contact save for a small area at one end. At that end the two (free) ends of the strips are gripped in the jaws of an instrument capable of measuring force and the strips are pulled apart as depicted schematically in Fig. 3. The portion of the adhesive subjected to stress at any instant is confined to a narrow zone paralleling the line of rupture.

3. Surface Tensile Test. A strip of paper is cemented to the flat face of a metal bar with shellac (hot-melt application), and the force required to pull the strip from the bonded area is evaluated with the strip at a definite angle with the plane of the metal bar. This test has been investigated on the Instrumentation Program and is discussed in Report No. 31, Part I (*3*).

4. Adhesive-Tape Test. A strip of adhesive tape, such as electricians' friction tape or "Scotch Cellulose Tape," is applied to a flat sheet of paper and then pulled off. There are at least three ways in which the test is employed: (a) The tape is jerked off and the operator studies the nature of the rupture in the surface coating, between the coating and the paper, or in the base stock. (b) The tape is pulled off at different speeds, and the strength of the coating is judged on the basis of an estimation of the speed below which no rupture occurs in or under the coating, and above which rupture occurs. (c) The tape is pulled off by means of an instrument capable of evaluating the force or energy required to effect the separation.

5. Tensile Test with Sheet Clamped at Periphery. Modifications of this test are described in Report No. 31, Part II (*4*) and by Halladay and Luey (*13*). The important difference between this test, which is schematically represented in Fig. 4, and the idealized tensile strength test depicted in Fig. 1 is that the sheet is not anchored under the bonded area and, accordingly, the stress which produces rupture is confined to a narrow zone bounded externally by the peripheral line of rupture.

6. Comparison Method. The resistance of a test sheet of paper to picking is compared with that of a reference sheet. This test has been described by Simmons (*16*): "Comparative tests may be run for pick by rolling up an unknown sample of paper against a known sample, using a brayer and a stiff ink. If the unknown picks and the known does not, the surface strength is weaker." This method assumes

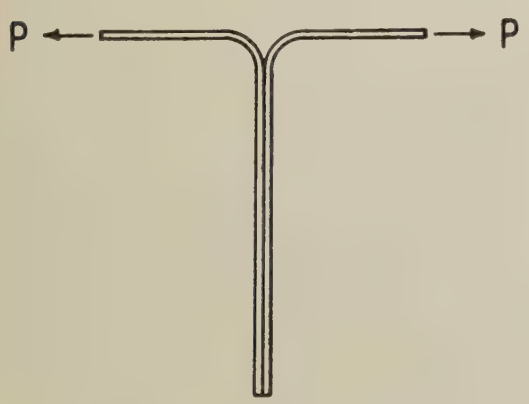

Fig. 3

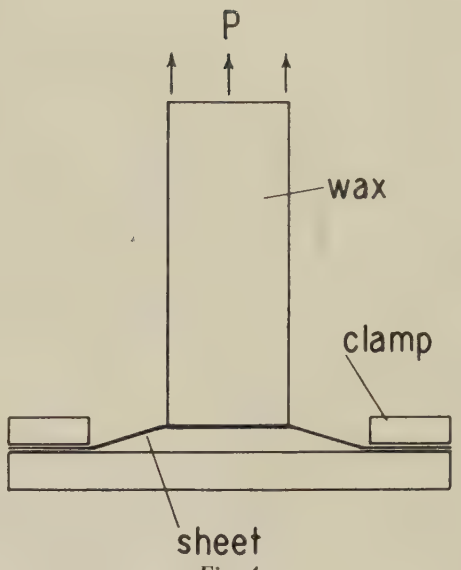

Fig. 4

that the stresses arising in the viscous action of the ink are the same on the two sheets.

7. Method Simulating Viscous Stresses in Printing. The apparatus and method for applying stress to a paper sheet through viscous action in very viscous materials are completely described and discussed in Report No. 31, Part III (*5*).‡

Discussion of the Methods

It is not expected that much of the data appearing in the literature on bonding strength (expressed in such basic terms as ultimate stress) is accurate. In comparative studies (particularly where the testing method closely simulates the bond in actual use), relative bonding strengths have been both reliable and useful. However, a consideration of the stresses in most of the tests which have been described leads to the conclusion that calculated ultimate stresses are erroneous. In this section some of the more important considerations will be presented.

Stress Intensification Due to Imperfections and Inclusions. Perhaps the most commonly recognized and generally important defect in the evaluation of strength of materials is the stress intensification occurring in either tensile or shear stress in the immediate vicinity of surface cracks, fissures, sudden changes of contour, internal voids or cavities, and foreign inclusions. An excellent account of stress intensification may be found in Part II of Timoshenko's "Strength of materials" (*20*). An illustration is presented diagrammatically in Fig. 5 which presents the stress trajectories of a material under tension. Each line represents the locus of direction of the stress. Uniform stress obtains when the trajectories are parallel and equally spaced; the stress is higher where the lines are crowed. In Fig. 5a the influence of a surface crack (which may be microscopic) is shown. It will be seen that the stress is greatly intensified at the apex of the crack. Depending on the sharpness of the apex, the local stress may be

‡ Since the war, this instrument has been redesigned with the principal view of obtaining an end point in a single determination. The new apparatus is described in Bulletin 34, issued by the American Newspaper Publishers Association, 370 Lexington Ave., New York 17, N. Y. (Oct. 17, 1950).

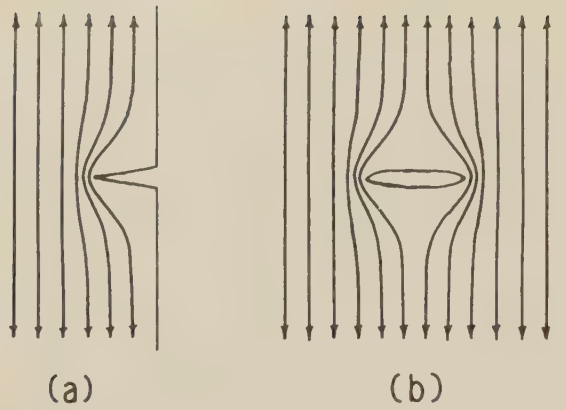

Fig. 5

from a few to many times the average stress in the specimen. If there is no other stress intensification as great as the one under consideration, failure of the material will commence at the apex; it is obvious that such failure will occur at an applied load P considerably less than that which would produce failure in material free of local stress intensification.

The similar influence of a cavity in the material is shown in Fig. 5b. It is not necessary for the cavity to be needlelike or ellipsoidal to produce an appreciable stress intensification. For example, a spherical cavity, such as a gas void, will cause a local increase of considerable magnitude.

If the cavity shown in Fig. 5b is due to a foreign solid, stress intensification will result (a) if the foreign body is not well bonded to the adhesive, or (b) if the modulus of elasticity of the foreign material is very different from that of the adhesive.

The foregoing discussion employed the illustration of a material under tensile stress. An exactly similar discussion holds for a material under shear stress.

It should be emphasized that the cracks, fissure, etc., referred to in this discussion need not be large to have possibly appreciable influence. In the case of glass at ordinary temperatures and waxes and many other substances at low temperatures, flaws of the sort discussed may be almost microscopic. The stress intensification produced by such flaws depends upon the *extensibility* of the material. Materials having large extensibility (of which rubber represents an extreme) are not "sensitive," since the cracks or other flaws are spatially extended in the direction of the stress, thus reducing the curvature where the stress is intensified. In at least a qualitative way, "brittleness" correlates with the vulnerability of a material to failure at imperfections.

Stress Intensification Due to Variable Thickness of Specimen. In the testing of an adhesive, as shown in Fig. 6a, or of the internal bonding strength of a single or multi-ply paper sheet, as shown in Fig. 6b, stress intensification of very appreciable magnitude may result from variability in the thickness of the test material if, as is usually the case, the stressing material (*b* in Fig. 6a and *a* in Fig. 6b) has a larger modulus of elasticity than that of the test specimen. For a given displacement of the stressing blocks, smaller thicknesses of the weaker material (the test specimen) undergo greater strain and, hence, experience greater stress. The case for a single sheet of paper is not exaggerated in Fig. 6b, for photomicrographs of cross sections of typical papers reveal large variations in thickness. The stress trajectories are concentrated in the thinner portions, and it is believed that local stress intensification may be of the order of twice the average stress. Accordingly, failure may initiate at an observed loading force very much smaller than would be measured if the thickness were perfectly constant. When rupture initiates, local stress intensification propagates in the usual manner with the zone of rupture, and overall failure quickly occurs.

Similar considerations hold for the testing of shear strength. In this case a given displacement of the stressing blocks results in greater shear strain and shear stress where the test material is thin.

Stress Intensification Associated with the Mechanical Properties of the Blocks, Bars, or Strips Through Which Stress is Applied. An important source of error in the testing of bonding strength in tension, shear, and in the special tests is the stress intensification resulting from the fact that the bodies through which stress is applied to the test specimen are not perfectly rigid. This section presents a discussion of sufficient examples of this effect to establish the principles as they relate to the testing of bonding strength.

In the testing of the tensile strength of a bond, the stressing blocks (or cylinders) may be inadequately short, as illustrated in Fig. 7. The stress trajectories are crowded at the center of the testing area and, in consequence, the stress in the central region is greater than average. If stress intensifications originating in the effects described in previous sections do not predominate in other regions, failure will occur in the central region at an observed load P less than that which would be measured if the stressing blocks were sufficiently long to yield a uniform distribution of stress trajectories. This effect is due to the fact that the material of the testing blocks is deformable—there is

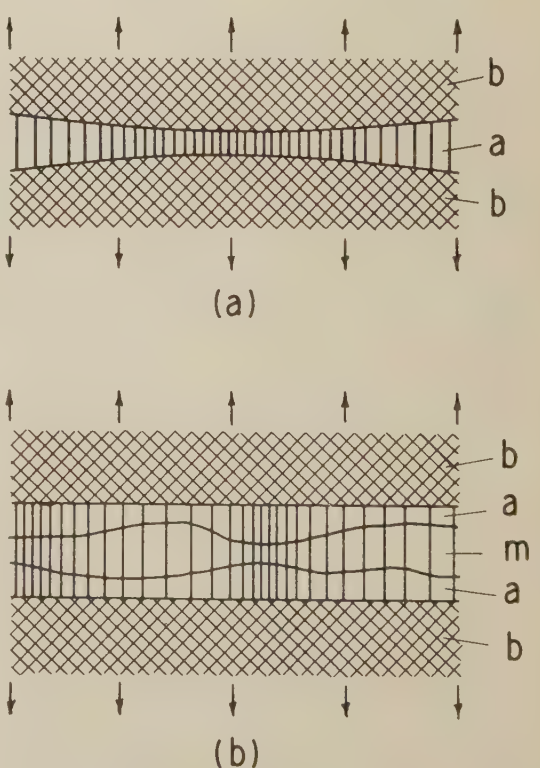

Fig. 6

no material which is not deformable. It will be seen at once that the effect is enhanced when the ratio of the axial length of the stressing blocks to the width or diameter is made smaller.

The effect of deformability of the stressing blocks, bars, or plates employed in the measurement of shear strength of bond is a little less self-evident. If the stressing bars (see Fig. 2) were perfectly rigid, the shear strain would be uniform, and the shear strength would be given by dividing the area of bond into the loading force P. Actually, the stressing bars yield, and the stress trajectories assume a form similar to that shown in Fig. 8 (a representation of the arrangement shown in Fig. 2b would exhibit similar characteristics). Between the plane A and the central plane C, the average stress in the bar b_1 is very much greater than that in bar b_2 and, in consequence, the elongation of bar b_1 between the planes A and C will be greater than that in bar b_2. Similarly, the elongation in bar b_2 will be greater than that in bar b_1 between the planes C and B. As a result, the shear strain applied to the bond will be maximum at the upper and lower ends of the bonded area (near the planes A and B) and minimum at the center of the bonded area. The stress intensifications are depicted by the crowding of the stress trajectories in the vicinity of A and B, where they pass through the bonded zone. It is clear that failure will initiate in one or the other of these regions, unless a stress intensification of one of the kinds described in previous sections predominates in another place. As in all cases where stress intensification obtains, the observed load P may be significantly less than that which would be measured with ideal bars. This effect would be enhanced by the use of either (a) *thin* stressing bars or strips, or (b) stressing bars or strips of an easily deformed material like rubber and many plastics. de Bruyne and others have published data showing the importance of this form of stress intensification (*21*).

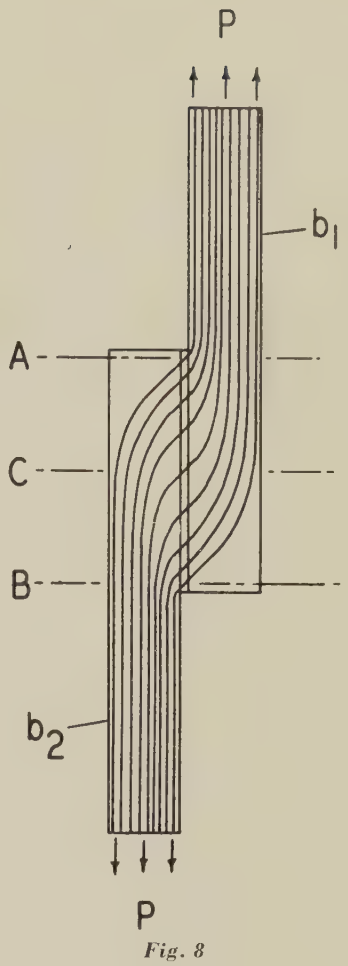

Fig. 8

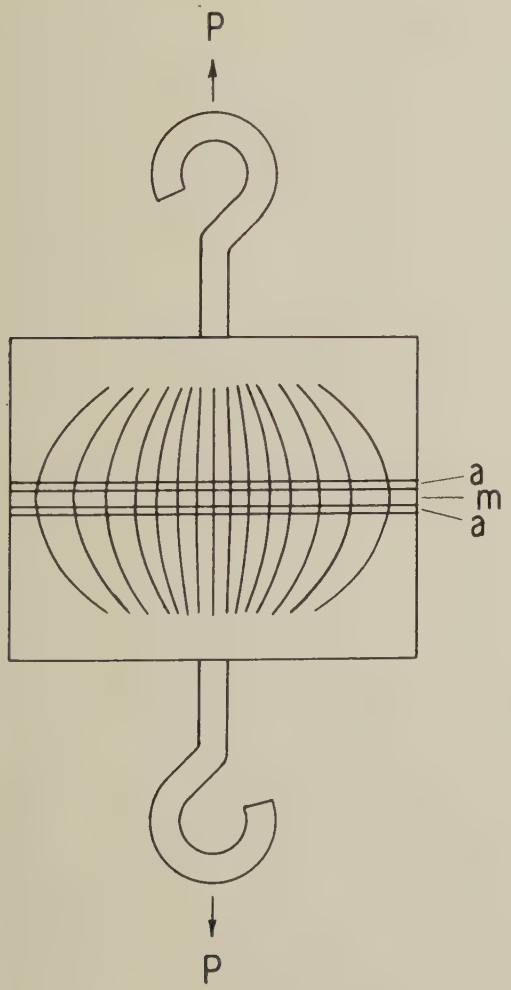

Fig. 7

In the commonly employed ply-adhesion test of the type shown in Fig. 3 the stress intensification is of great magnitude, and is importantly influenced by the flexural rigidity of the strips to which the separating force P is applied. Figures 9a and 9b present the approximate cases for strips of low and high flexural rigidity, respectively. There will be a large stress intensification along the line of rupture r. It seems probable that the greater radius of curvature of bend of the *stiffer* strips will result in a more extensive zone over which the stress is distributed and, hence, in less stress concentration. Therefore, insofar as this effect alone is concerned, a *greater* force P should be observed when *stiffer* strips are employed. However, other factors are involved. In the case of the stiffer strips, the line of action of the loading force P is farther removed from the zone of rupture and, hence, the bending moment will be greater (for the same force P) at points near r. This bending moment may be equated to an integration of incremental moments resulting from tensile (positive) stresses in a narrow zone near r and compression (negative) stresses in an adjacent zone

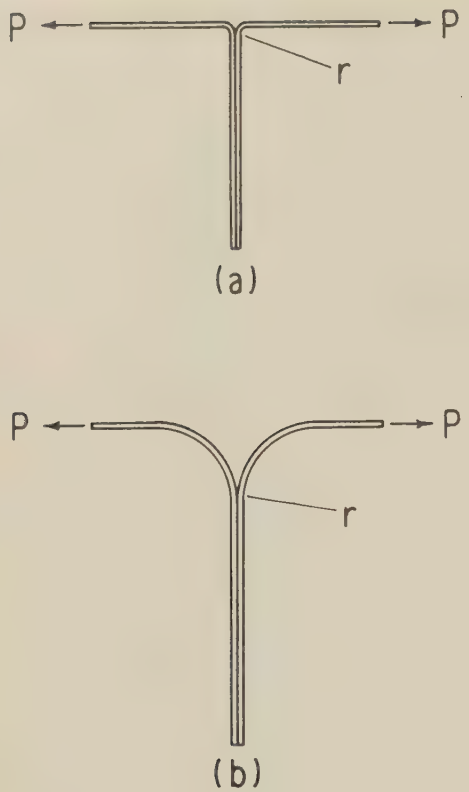

Fig. 9

of indefinite extent (in which the compression stress diminishes rapidly with distance away from the zone of tensile stress). The existence of compression stress necessitates a greater total tensile force than would obtain in the case of strips of zero flexural rigidity (where there would be no compression stress and the total tensile force would be equal to P). Accordingly, the total tensile force in the zone of rupture increases with the stiffness of the strips, although this does not necessarily result in an increase in the maximum *stress*. Information is needed concerning the influence of stiffness of the strips on distribution of stress over a distance away from r. In any event, it seems clear that the testing of bonding strength by this method is subject to a possibly serious error, the magnitude of which is a function of the stiffness of the testing strips.

A similar discussion applies to the following tests (referred to in a previous section): surface tensile test, adhesive-tape test, and tensile test with sheet clamped at the periphery (Fig. 4). As ordinarily employed, the adhesive-tape test is only qualitative in nature; however, devices have been employed to evaluate either the force or the energy required to pull or jerk adhesive tape from a paper surface and, in such apparatus, a variable of importance is the stiffness of the adhesive tape. If the paper is not properly mounted or clamped, the stiffness of the paper would also be an important variable. (It is not within the scope of the present report to discuss such variables of the adhesive film as adhesive strength, viscosity, film thickness, and strength of bond between the adhesive film and tape material.) In the special type of tensile test depicted in Fig. 4, the stiffness of the sheet influences the maximum stress around the circular zone of rupture, as discussed in the previous paragraph. In addition, however, there is a complicating factor associated with the angle of rise of the paper in the zone between the clamp and the wax (exaggerated in Fig. 4). The maximum stress for a given observed force will obviously depend on this angle which, in turn, is a function of the stiffness of the paper. The angle will also depend on the diameter of the waxed area. Halladay and Luey (*13*) have found that the linear relationship between observed force and diameter of the waxed area (which may be explained in view of the direct proportionality existing between diameter and circumference) breaks down when the diameter is large. Possibly this deviation from linearity is due to increasing steepness of angle of the paper with increasing diameter.

The purpose of the foregoing discussion is to stimulate better instrumentation for the measurement of adhesion. It has been shown that stress intensification can exist in supposedly fundamental tests and in special "use tests" as a result of several different effects. It is reasonable to expect that stress intensification can be responsible for gross errors in the evaluation of adhesion.

SUGGESTIONS FOR IMPROVEMENT OF INSTRUMENTATION OF ADHESION MEASUREMENT

A critical discussion of existing instrumentation naturally implies improvements in both method and apparatus. The principal improvements and precautions are here outlined with respect to (a) *stressing elements*, (b) *test specimen—adhesive*, (c) *test specimen—adherend*.

Stressing Elements

The stressing elements (blocks, cylinders, bars, strips) may, or may not be a specific and integral part of the bond under test.

1. Tensile Test (Fig. 1). The solid blocks or cylinders should have a cross section of uniform shape and area over a substantial distance away from the bond; this distance should be at least several times the larger dimension of cross section in the case of rectangular blocks, or several diameters of the circular cross section in the case of cylinders. The material of the stressing elements should have a sufficiently large modulus of elasticity in tension and small Poisson's ratio to suffer negligible reduction in cross-sectional area under the stresses required to break the bond. If the test specimen is an adhesive, and the adherend must (as is usually the case) be a specific material, the adherend should not be the material of the stressing elements unless it meets the foregoing qualifications; if it fails to meet those qualifications, it should be employed in the form of thin layers "sandwiching" the adhesive and bonded to the stressing elements with an adhesive of greater strength of bond than that existing between the adhesive and adherend. *Any such thin layers should have very uniform thickness.*

Similar comments apply to compression testing. In compression testing, the column stability of the stressing elements must be considered; greater length of the elements results in greater uniformity in stress distribution but also causes greater instability of the compressed system. The over-all length of the stressing elements should be not greater than that which is considered stable.

2. Shear Strength (Fig. 2b). The bars should

have equal and uniform width, and the cross section should be uniform over a substantial distance away from the bond; this distance should be at least several times the width of the bars. The material of the bars should have a high modulus of rigidity, and the thickness of the bars should be sufficiently great to minimize, as far as possible, the stress concentration resulting from strain in the bars. If the test specimen is an adhesive and the adherend must be a specific material, the adherend should not be the material of the bars unless it is adequately rigid and is available in substantial thickness. (It is assumed that a fundamental test of shear strength is here involved—the situation is obviously different in the case of a "use test.") If the adherend is not suitable for the stressing bars, it should be employed in the form of thin layers of very uniform thickness sandwiching the adhesive, and bonded to rigid, thick stressing bars with an adhesive of greater shear strength than that of the adhesive under test.

3. Special Tests. In such special tests as the ply-adhesion test illustrated in Fig. 3, the material of the strips should be standardized as to type, stiffness, and thickness (in addition to standardization of such structural properties as porosity, smoothness, etc.). In the case of paper strips, it is known that specification of stiffness is not adequate, for two sheets having the same stiffness will often exhibit different bending quality (which relates to the uniformity and strength of a folded zone when the paper is bent to rupturing curvatures); hence, the paper should be standardized with respect to bending quality. It should be remembered that, in a given sheet of paper, both the stiffness and the bending quality are critically dependent on the direction in the sheet from which the strips are cut—for example, strips cut in the across-machine direction possess roughly half the stiffness of strips cut in the machine direction, and have superior bending quality. Similarly, in any attempt to employ the adhesive-tape test in quantitative work, the stiffness, thickness, and bending quality of the backing tape should be standardized (in addition to standardization of the thickness, viscosity, and adhesive strength of the adhesive film and the strength of bond between that film and the backing tape).

Test Specimen—Adhesive

1. Where it is desired to measure a fundamental strength of the adhesive, such as tensile strength and shear strength, the adhesive should contain no air or gas bubbles or small particles of foreign matter, however small such imperfections may be. (The importance of this consideration obviously depends upon the sensitivity of the adhesive to premature failure owing to stress concentration, which, in turn, is related to brittleness.) Where such imperfections are considered to be an intrinsic characteristic of the adhesive, the only precaution to be observed is that the method of testing should not introduce extra imperfections.

2. The thickness of the film of adhesive between the stressing elements should be very uniform. Such uniformity will be largely controlled by the flatness of the surfaces of the stressing elements and by the methods of applying the adhesive and forming the bond.

3. Any trimming of material from the periphery of the bonded area (to render the latter definite in value) should be done in such manner as to leave the surface of the cut edge of the film of adhesive as free as possible of minute scratches, pits, and other imperfections.

Test Specimen—Adherend

The adherend of usual interest to the papermaker is a single sheet of paper or a multi-ply paper consisting of two or more sheets bonded together with an adhesive or, in the case of paper-base plastics, a number of resin-impregnated paper sheets bonded together under pressure at elevated temperature. The adherend must be bonded to the stressing elements by means of an adhesive of greater strength than that of the adherend. Ultimate failure may occur in the sheet material or, in the case of multi-ply paper, in either the sheet material or the laminating adhesive.

1. The test specimen must have uniform thickness. If, as is the case in most papers, the thickness varies greatly from point to point, the tested area should be selected on the basis of one or both of the following suggestions: (1) The tested area should be sufficiently small to result in a region having essentially constant thickness, as checked by means of an accurate thickness gage equipped with a small foot. (2) On the basis of a number of measurements with an accurate thickness gage equipped with a small foot, areas of test should be selected with regard to uniformity of thickness.

2. In the case of impregnated papers, with particular reference to papers impregnated with materials sensitive to stress intensification, the peripheral surface bounding the tested area should be free of minute scratches, pits, and other imperfections. (Ordinary papers are filled with minute voids and, accordingly, should not be sensitive to such peripheral imperfections.)

3. If the adherend is evaluated in a special test, like the ply-adhesion test illustrated in Fig. 3, the results obtained will depend upon the stiffness and the bending quality of the paper or other sheet material, as previously discussed. It is important, therefore, to determine the principal directions of the sheet and standardize on the direction in which the strips are to be cut.

DISCUSSION OF FACTORS RELATING TO USE REQUIREMENTS

The evaluation of bonding strength is not complete unless the method encompasses factors brought into play in the actual use of the bond. Such factors as temperature and relative humidity of conditioning and testing and water adsorption are well known, and are commonly controlled. Global warfare has extended the ranges of conditioning and testing. Many materials are now tested after immersion in water (of stated purity or composition) for definite periods of time; materials are conditioned and tested at temperatures from the order of −100 to 180°F. or higher; the relative humidities of conditioning rooms and chambers now cover nearly the complete range from zero to 100%. The influences of these factors on the strength of most organic materials are profound, and it is clear that the testing of bonding strength is meaningless unless done with full recognition of those influences.

The influences of cyclic changes in moisture content and temperature are also recognized, and a number

of existing procedures for the testing of materials prescribe definite schedules for temperature, water immersion, and relative humidity. The structural changes caused by alternating wetting and drying and cooling and heating are apt to be of particular importance in the case of bonding of materials *in view of the different properties of the adhesive and adherend.* In virtually all cases the thermal expansion coefficients and hygroexpansivities of the adhesive and adherend are different and, hence, each of the two materials will be strained by the other; in some cases the strain may be sufficiently great to produce rupture—for example, the swelling of cellulosic fibers by water may be sufficient to disrupt an adhesive or impregnant, and differential expansion or contraction may produce minute fissures in a brittle adhesive (it should be recalled that most relatively flexible materials become brittle at low temperature). Small or even microscopic cracks and fissures produced by changes in temperature or moisture content will cause serious stress intensification and a lowered bonding strength may consequently be observed.

Time plays a very important role. Paper and other materials are frequently evaluated before and after a period of natural or accelerated aging. It would seem that aging should be of particular importance in the evaluation of bonding strength. It is a common property of organic materials to undergo a gradual shrinkage with time and, where two materials are bonded together, the strains established by differential shrinkage may be disruptive after a period of time. Even where such differential shrinkage does not result in actual rupture, it is possible that the strength of bond would be greatly affected.

Creep in materials under continuous loading is fortunately receiving more widespread attention [a very lucid discussion of creep has been prepared by Leaderman (*22*)]. A number of materials which appear to have good adhesive properties on the basis of ordinary (short-time) tests may creep badly under continuous loading, and fail after a disappointingly short period of stressing. The phenomenon of creep is profoundly influenced by temperature (it has been possible to associate an "energy of activation" for a number of materials) and by moisture content in the case of hygroscopic substances (*22*). High melting-point asphalt is a classic example of a material displaying strong creep. A joint formed with asphalt may hold under a given load almost indefinitely if the temperature is sustained at a low value, and the joint may appear strong in an ordinary (short-time) test at room temperature; however, the joint may fail at room temperature under moderate loading after only minutes or hours. The actual measurement of creep in a *film* of adhesive may be difficult in view of the smallness of the displacement. It is probable that useful data might be obtained with either of at least two procedures: (a) Measure the time over which the bond will hold when stressed continuously under a constant, predetermined load. A relationship should be established between time and apparent stress. (b) Measure the bonding strength after a predetermined time of stressing under a predetermined load. This second procedure might have certain advantages, but has the disadvantage of bringing three variables into play; three relationships between pairs of the variables could be established: (1) time constant, (2) load constant, and (3) final bonding strength constant. The last relationship would be the same as that referred to in procedure (a) in the special case where the final bonding strength is zero.

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Calendar of TAPPI Meetings

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Third Coating Conference, Sherman Hotel, Chicago, Ill., May 5–8, 1952.

Seventh Engineering Conference, Morrison Hotel, Chicago, Ill., October 13–16, 1952.

Alkaline Pulping Conference, Mobile, Ala., November 12–14, 1952 (Tentative).

LOCAL SECTIONS

LAKE ERIE SECTION:
May 22–23, 1952. Carter Hotel, Cleveland, Ohio.

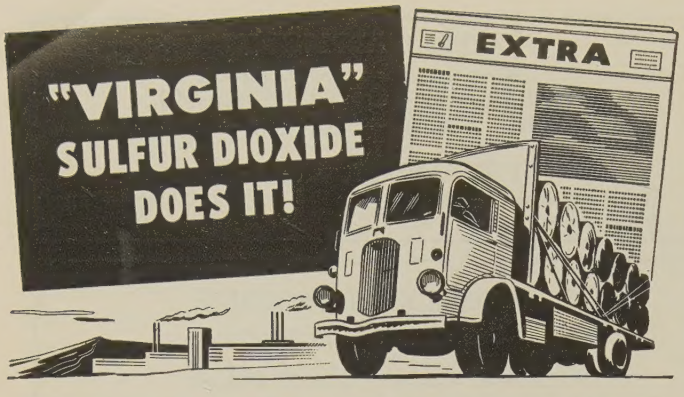
DELAWARE VALLEY SECTION:
April 24, 1952, Engineer's Club, Philadelphia, Pa.

OHIO SECTION:
May 8, 1952, Middletown, Ohio.

NEW ENGLAND SECTION:
May 16–17, 1952, Toy Town Tavern, Winchenden, Mass.

MAINE-NEW HAMPSHIRE SECTION:
June 20–21, 1952, Belgrade Lakes House, Belgrade Lakes, Maine

EMPIRE STATE SECTION:
(Eastern District) May 22, 1952, So. Glens Falls, N. Y.
(Central District) May 2, 1952, Syracuse, N. Y.
(Northern District) May 8, 1952, Watertown, N. Y.
(Metropolitan District) May 13, 1952, Fraunces Tavern, New York, N. Y.
Annual Meeting, June 18–21, 1952. General Brock Hotel, Niagara Falls, Ont.



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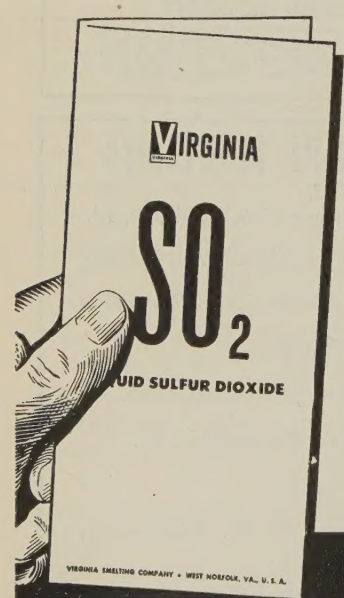

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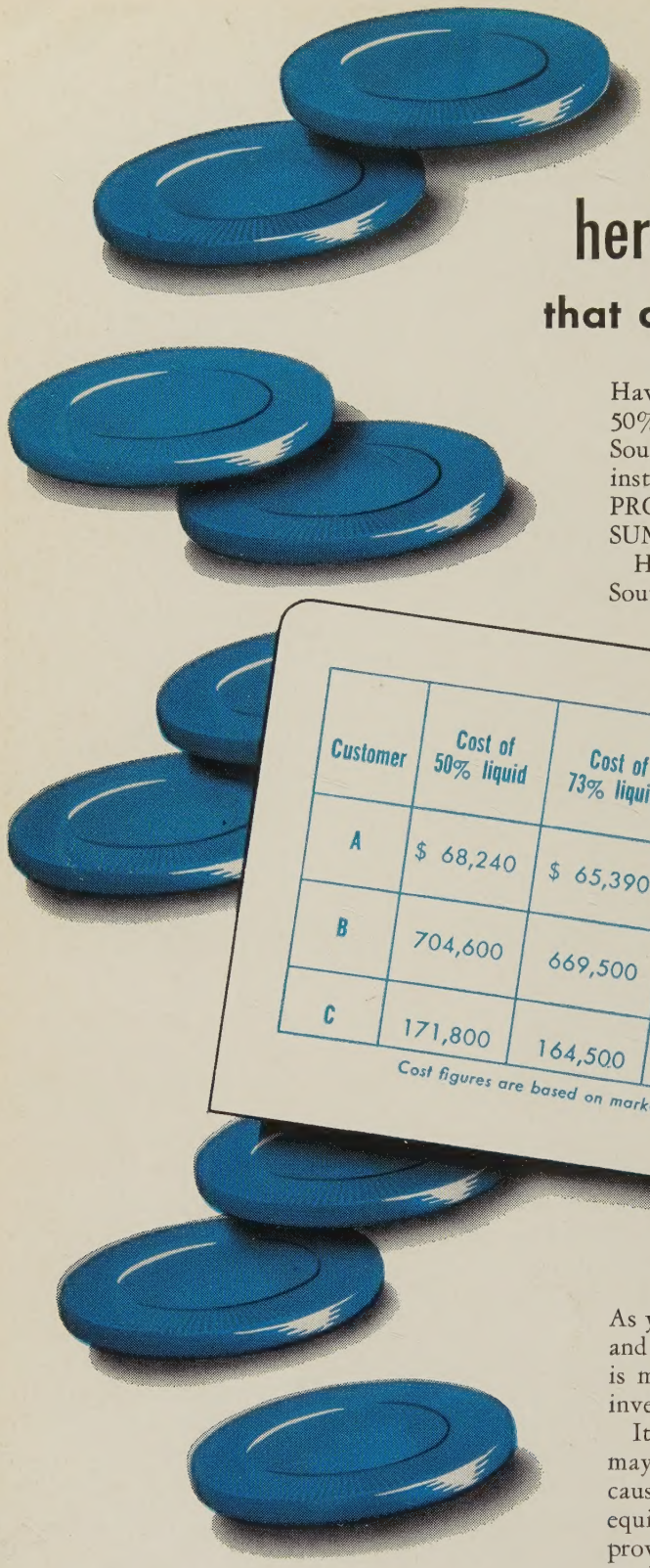

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